<u>Exploratory Study</u>

Assessment of OSW's 35% Municipal Solid Waste Recycling National GPRA Goal for 2005

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Disclaimer

This document presents the findings of an exploratory study conducted Summer 2003, involving a literature review, secondary data collection, and secondary analysis (i.e. analysis of reports, documents, books, and journal articles authored by other persons with goals generally different from the objectives of this study). Because of its exploratory nature, the contents of this study document do not represent official US EPA policy, nor do the references contained in this document constitute endorsement of particular authors, organizations, methods, information or data. The individual author identified on the title page is solely responsible for the scope, design, analyses, findings, format and contents of this document.

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Summary

OSW's RCRA solid waste authority assigns resource recovery (e.g. waste recycling) responsibilities to state government planning (i.e. RCRA Subtitle D resource recovery), and to the US Dept of Commerce (i.e. RCRA Subtitle E development of materials recovery technologies & commercial markets). However, in 1988, OSW challenged the nation to recycle 25% of MSW by 1992, and in 1996 proposed a 35% goal for 2005. The purpose of this exploratory study is to assess the feasibility and economics of achieving the 35% goal relative to the 2000 national MSW recycling baseline of 30% to 32% (i.e. 70 to 130 million tons recycled of 232 to 409 million tons generated, respectively), using existing published data on US state- and US city-wide MSW recycling performance measures.

As of 2000, state MSW recycling rates ranged from 1% (OK) to 59% (DE), and the 25 largest US cities ranged from 2% (Dallas) to 56% (San Francisco). Statewide MSW curbside recycling program population coverage ranged from 0% (AK) to 100% (CT), averaging 52% of the US population.

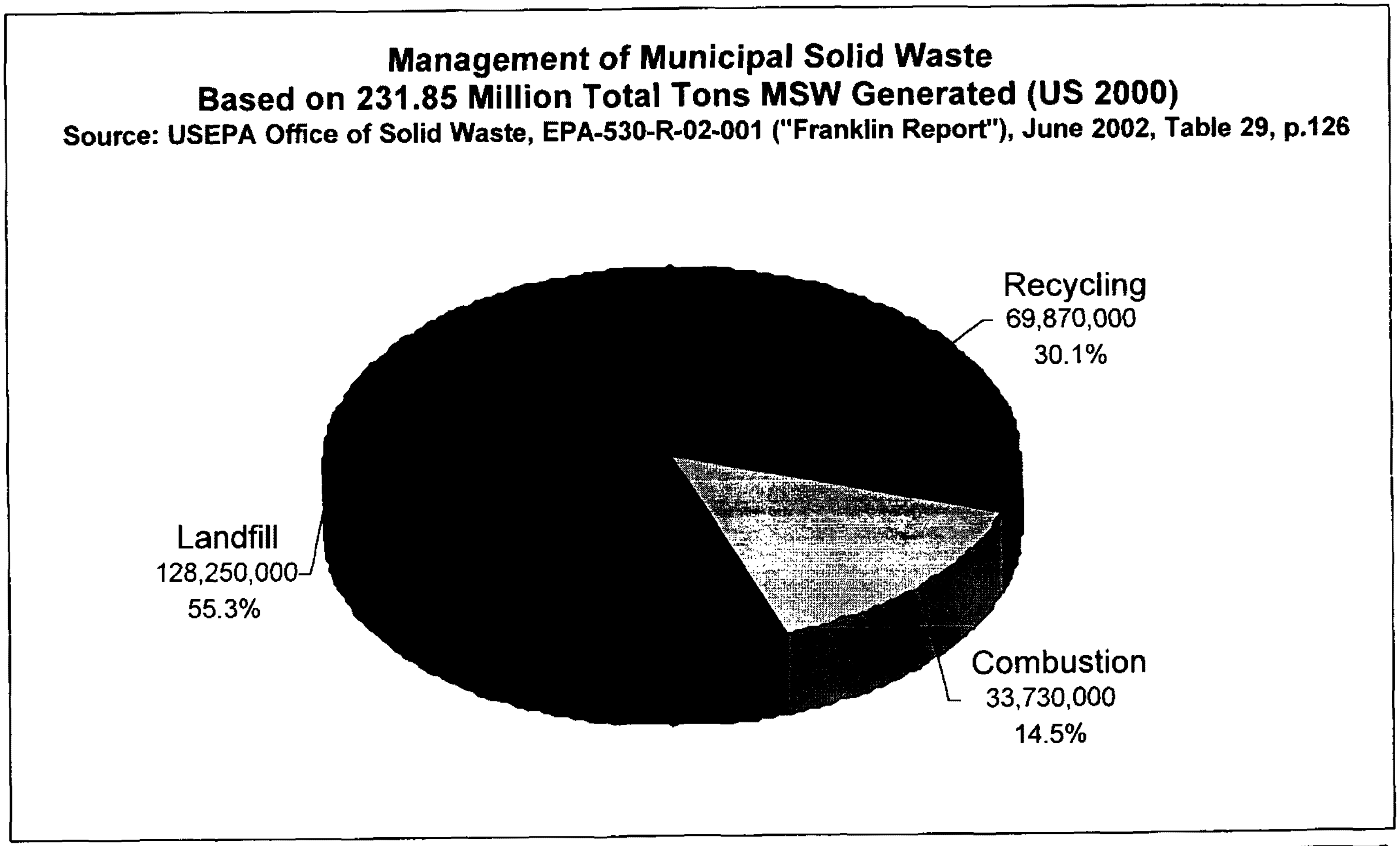
Based on +/-1 standard deviation statistical intervals from a pooled data sample of 30 city-wide MSW recycling program costs (@$35 to $162/ton), and five recycling benefit categories (@$226 to $544/ton), this study estimates that an incremental $420 to $1,900 million in annual cost is needed to recycle an additional 12 million tons/year of MSW to reach the 35% goal, which would generate $2.3 to $4.6 billion in additional annual net benefits, representing a benefit-cost ratio (BCR) of 3.4 to 6.4.

This study projects an economically-beneficial recycling "net cost" threshold of 225$/ton (for minimum BCR =1), and projects a future potential national MSW recycling rate ranging between 40% to 45% based on meeting current unmet statewide goals, to 46% to 49% from expanded program coverage to all large + small urban populations.

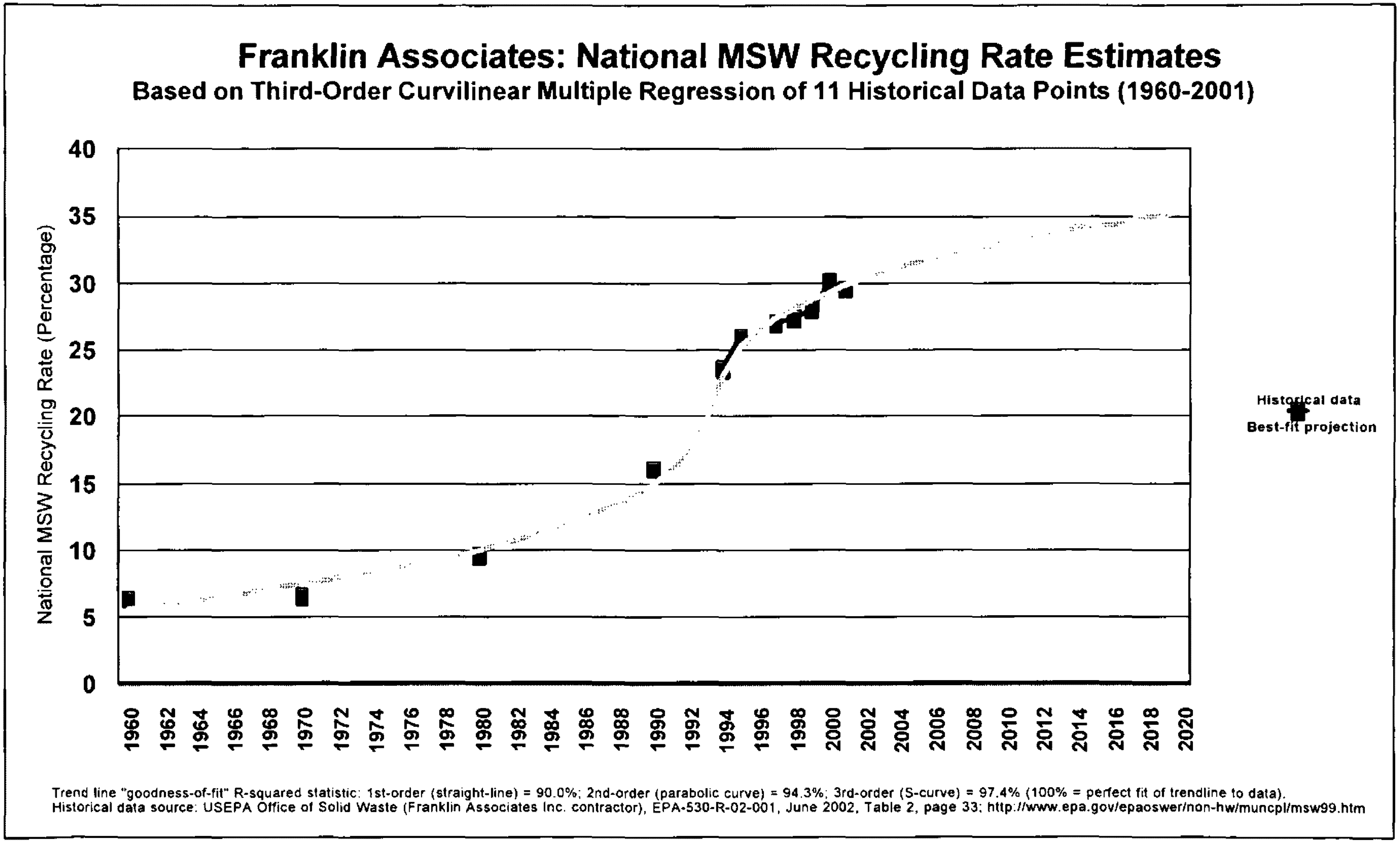
I. OSW MSW RECYCLING POLICY ISSUE:

Is OSW's Year 2005 GPRA National Goal of 35% MSW Recycling Achievable?

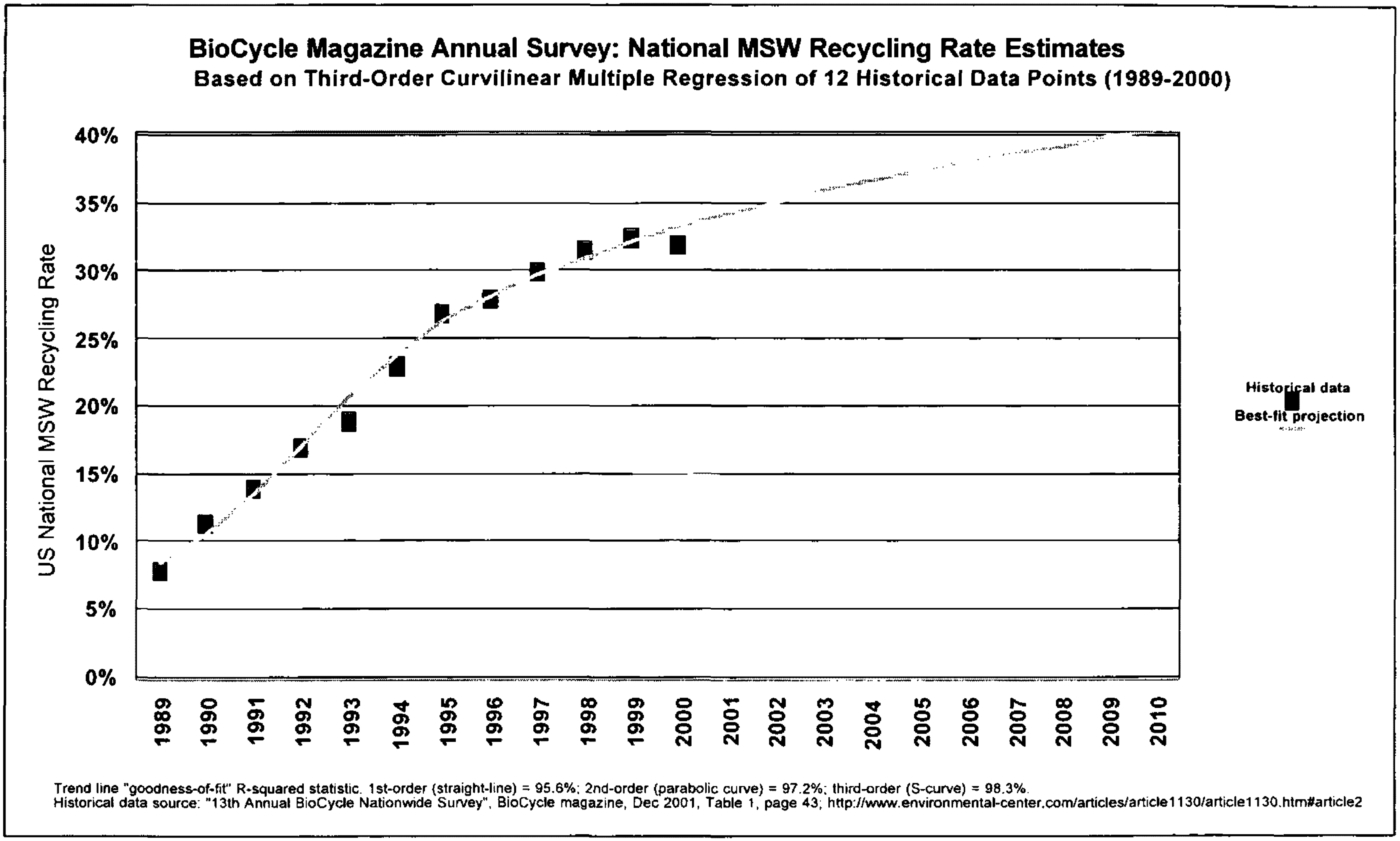
Big Picture Snapshot of MSW Management (US Year 2000)



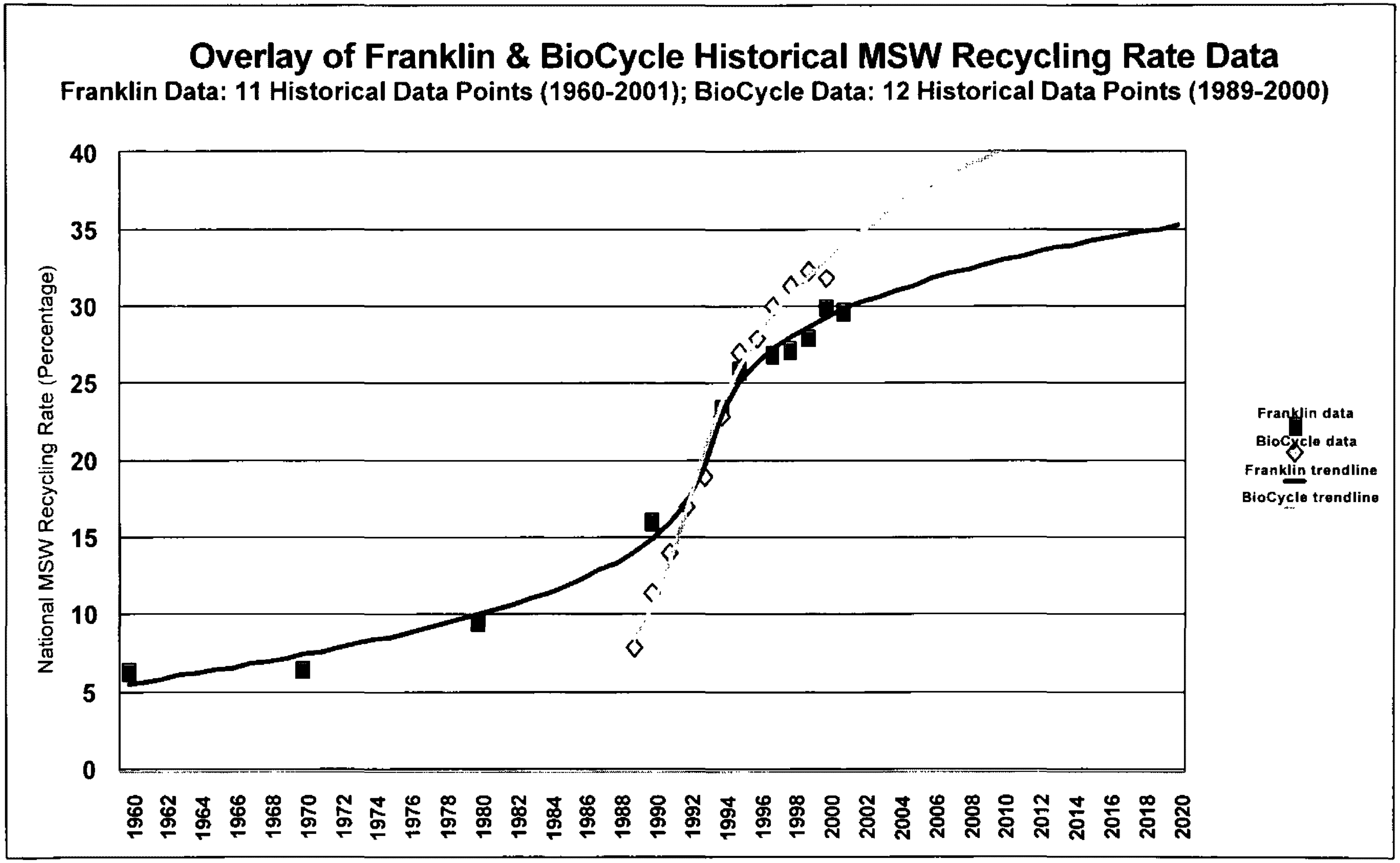
Future Projection #1 of 2:
-- Franklin trendline suggests 35% in 2018 w/out re-measurement or stimulation



Future Projection #2 of 2:
-- BioCycle magazine historical trendline suggests 35% by year 2003!!!



Overlay of Franklin & BioCycle Historical Data Series



Which Future Recycling Rate Projection is “Correct”?

Franklin Associates data

> 35% recycling by year **2018**

Baseline (2000 data year; all states):

- 30.1% MSW recycled
- 231.9 million TPY MSW generated = 0.82 TPY/person
- 69.9 million tons recycled
- Increment to 35% = (35%-30.1%) x 69.9 = 11.4 million tons/year

Data (Measurement) Scope:

- Includes:
  - Composting (but not backyard composting)
  - Commercial
  - Institutional
  - Industrial office/food/packaging
- Excludes:
  - Construction & demolition debris
  - Biosolids (sewage sludge)
  - Scrap autos
  - Motor oil
  - Agricultural
  - Industrial process wastes

BioCycle magazine data

> 35% recycling by year **2003**

Baseline (2000 data year; 47 states):

- 31.9% MSW recycled
- 409.0 million TPY MSW generated = 1.45 TPY/person
- 130.5 million tons recycled
- Increment to 35% = (35%-31.9%)x409.0 = 12.7 million tons/year

Data (Measurement) Scope:

- Excludes:
  - Composting
- Includes:
  - C&D debris (wood, asphalt, concrete)
  - Biosolids (9 states)
  - Scrap autos (2 states)
  - Motor oil (11 states)
  - Agricultural (14 states)
  - Commercial (47 states)
  - Institutional (43 states)
  - Industrial process residuals (24 states)

Benchmark: Recent International MSW Recycling Rates

Europe:

- Austria (1999) 64%
- Belgium (1998) 52%
- Germany (1999) 48%
- Netherlands (1999) 47%
- Denmark (1999) 39%
- Finland (1997) 33%
- Sweden (1998) 33%
- Spain (1999) 27%
- Italy (1997) 16%
- France (1998) 14%
- U. Kingdom (1999) 11%
- Portugal (1999) 9%
- Greece (1997) 8%

Other Countries:

- Canada (2000) 24%
- Japan:
  - 1992 4%
  - 1995 10%
  - 2002 65%

Note: The basket of wastes included in recycling rates varies between countries.

International MSW Recycling Ideologies: Two Contrasting Examples

- Pro (Japan): In June 2000, the Government of Japan began implementing "*The Basic Plan for Establishing a Recycling-Based Society*", providing a 10-year program to promote comprehensive and systematic policies aimed at changing unsustainable patterns of production and consumption: "to reduce the amount of resources that are removed from nature as much as possible, and to reduce the amount of things that are finally discarded in nature as much as possible by inputting things once used in society as recycled resources." [http://www.env.go.jp/recycle/circul/kihonho/law-e.pdf].

- Con (Sweden): In Nov 1999, the Swedish Government Finance Department published a report titled "*Recycling: Not Worth The Effort*", which concluded: "The social value of recycling beyond the level motivated by market forces rests solely on its positive contribution towards environmental standards, or to sustainability if depletion is a problem. Environmental evaluations reveal that paper burning and glass and metal landfilling, for example, are superior to recycling in environmental terms, so the net effect of additional recycling of these waste flows is detrimental to the environment. Cost-effective policies to improve environmental conditions should aim at directly enhancing these conditions, and only in rare cases would recycling across the board emerge as an efficient policy tool" [http://finans.regeringen.se/eso/PDF/ds99_66.pdf].

II. ASSESSMENT OF MSW RECYCLING

The Resource Conservation & Recovery Act (RCRA) assigns primary responsibility for recycling and all non-hazardous waste policy decisions to state governments. Consequently, recycling initiatives and recycling programs in the US are not uniform, since they are designed and implemented at the state and local levels. This in turn means that **any economic analysis of recycling must rely on local observations and, to assure that the results can be generalized, must control for community- and region-specific influences and factors**.

Source: Scott Callan & Janet Thomas, Bentley College, "The Impact of State and Local Policies on The Recycling Effort", Eastern Economic Journal, Vol. 23, No. 4, Fall 1997, p.411.

MSW Recycling Goal Assessment Methodology

- Timeframe: Initial two-month timeframe (April & May 2003) set by OSW MISWD recycling team, for EMRAD to conduct this assessment; scope of EMRAD part-time work on this study expanded thru Aug 2003, as new literature sources became available from inter-library loan sources.

- Scope: Evaluation "Option 2" was initial EMRAD study scope & framework for this assessment; evaluation scope expanded to include internet info/data search (per "Option 3"), and benefit-cost analysis (per "Option 4"); Appendix C contains the four study plan options.

- Staff: One EMRAD staff economist (Mark Eads) conducted this project in-house (no contractor support). Information contributions by MISWD staff, MISWD contractor (Franklin Associates), and OSW Regional Implementation Team (RIT).

- Data: Recycling assessment limited to secondary information sources on recycling baseline, recycling infrastructure, & recycling costs/benefits (no new data collected).

Secondary Information Sources Consulted/Collected

Sources:

- MISWD staff
- Franklin Associates
- EMRAD staff
- OSW Regional Implementation Team (RIT) conference call
- Internet search
- EPA HQ library
- Interlibrary loans

Categories:

- Peer-reviewed academic journal articles
- Recycling news
- Trade/industry magazines
- EPA reports
- White papers (e.g. local/state govt's, NGOs)
- State technical guidance
- Case studies (e.g. cities, recovered material markets)
- US regional studies (e.g. NE)
- International items

ASSESSMENT ISSUE #1:
Recycling Rate Measurement

Caveat Emptor: Recycling Rate Measurement Variability

"Currently, not everyone defines recycling or the processes that constitute recycling in the same way. Definitions of MSW [municipal solid waste] also vary. There is no standard approach for how or where to collect the needed data. **The methods used to calculate a recycling rate also differ from one area to another**. All of these factors can make it difficult to collect and analyze data and to compare the effectiveness of recycling programs from one region to another."

Source: USEPA Office of Solid Waste, "Measuring Recycling: A Guide for State and Local Governments", EPA-530-R-97-011, Sept 1997, 160 pp.
http://www.epa.gov/epaoswer/non-hw/recycle/recmeas/download.htm

Recycling & Related Concepts (USEPA definitions)

- Waste recycling: the series of activities by which discarded materials are collected, sorted, processed, and converted into raw materials and used in the production of new products; excludes the use of these materials as a fuel substitute or for energy production.
- Waste generation: amount of materials and products that enter the wastestream (e.g. from residential, business/commercial, institutional, and industrial sources) before recycling, reuse, composting, landfilling, or combustion takes place.
- Waste reuse: use of a product or component of waste in its original form more than once (e.g. refilling glass or plastic bottles, repairing pallets).
- Waste recovery: removal (capture) of materials from the wastestream for diversion from disposal into recycling, composting, or reuse.
- Discards: materials remaining in wastestream after recovery.
- Waste disposal: ultimate disposition (emission) of discards (non-recovered materials) into the environment (air, land, water) as "sink".

Standard MSW Recycling Rate (USEPA definition)

$$\text{MSW recycling rate (\%)} = \frac{\text{(quantity MSW recycled)}}{\text{(quantity MSW generated)}} \times 100$$

Recycling Rate Measurement Issues Implied From 14 May 2003 Franklin Assoc. Briefing to OSW

- Recycling Sources: EPA's scope for MSW not exclusively "municipal"; includes commercial, institutional, & some industrial (e.g. wood pallets); could be revised as four separate category sensitivity analyses.

- Recyclable Materials: Excludes a number of waste streams that others may classify as MSW: construction & demolition debris, used oil, medical waste, pre-consumer waste; could be included as sensitivity analysis.

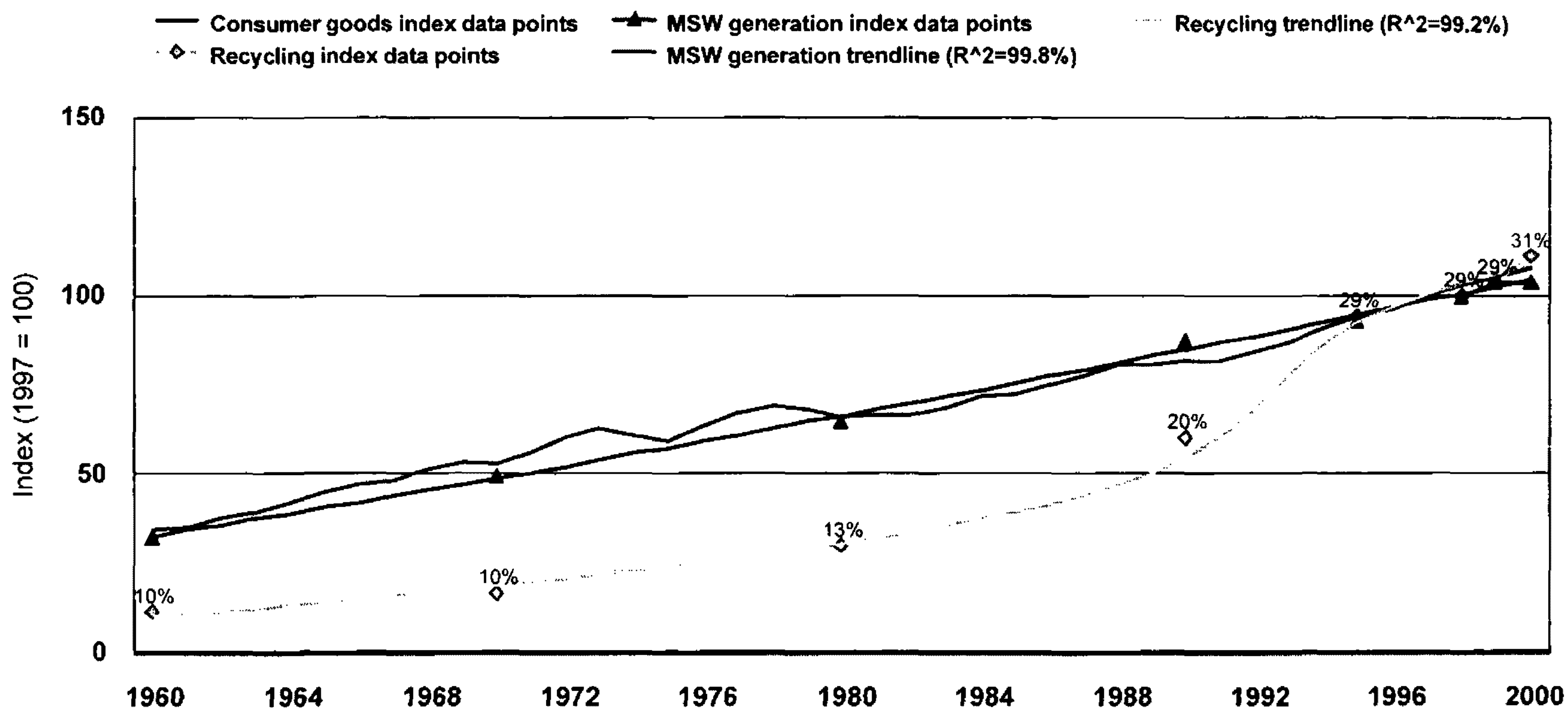
- Materials Reuse/Energy: Excludes materials reuse (e.g. retreaded tires), source reduction substitution (textiles or container reuse), waste-to-energy (e.g. pallets), backyard composting, and land applications; could be included as sensitivity analysis.

- Assumptions: Some key numerical assumptions for estimating the annual recycling rate, were formulated in early-1990s; could be updated.

- Uncertainty: Possible to introduce uncertainty ranges in numerical values of some key assumptions, and carry-thru ranges to annual recycling rate estimates, rather than single point estimates each year.

Recycled Quantity Divided by MSW Generated = "Recycling Efficiency"
MSW Generated Divided by Consumer Goods Production = "Recycling Availability"

Comparison of MSW Generation* & Recycling* Quantities to US Consumer Goods Production Index



* MSW generation index in this table only includes material products; excludes yard trimmings, food, misc inorganics (soil, stones, concrete), & other non product materials.
MSW generation & recycling data source: EPA-530-R-02-001 (Tables 1 & 2); http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm
IPI data source: Economic Report of the President, Feb 2003, Table B-52; http://w3.access.gpo.gov/usbudget/fy2004/pdf/2003_erp.pdf

ASSESSMENT ISSUE #2:
Recycling Rate Stimulation

2A. MSW Recycling Baseline (2000)

2A.1 Statewide Recycling Rates & Goals
2A.2 City Recycling Rates
2A.3 Materials Recycled
2A.4 Recent Policies & Options for Affecting Rates

2A.1
Statewide Recycling Rates & Goals

MSW Recycling Rates for States (2000)

1. DE 59%
2. AR 45%
3. NY 42%
4. CA 42%
5. MN 42%
6. ME 40%
7. OR 39%
8. NJ 38%
9. MA 38%
10. MO 38%
11. MD 37%
12. WI 36%
13. IN 35%
14. WA 35%
15. TX 35%
16. IA 35%
17. TN 34%
18. PA 33%
19. VT 33%
20. SC 31%
21. KY 30%
22. VA 29%
23. FL 28%
24. IL 28%
25. NC 26%
26. WV 25%
27. RI 24%
28. HI 24%
29. AL 23%
30. NE 23%
31. CT 23%
32. NH 21%
33. OH 21%
34. MI 18%
35. AZ 17%
36. LA 17%
37. MS 16%
38. NV 14%
39. ND 11%
40. WY 10%
41. NM 9%
42. CO 9%
43. KS 9%
44. AK 8%
45. UT 5%
46. OK 1%

Source: BioCycle magazine, Dec 2001, Table 3, page 45

Note: states vary in what they include (measure) in their recycling rates.

Data not available from source for GA, ID, MT, SD

Provision of MSW Recycling Services (US 1995)

Provider of Service	National Prevalence* Curb	Com	Drpoff	Proc
▪ Local government program	40%	14%	16%	9%
▪ Local gov't contractor	42%	15%	25%	30%
▪ Gov't franchise to single firm	9%	6%	4%	5%
▪ Private firms w/out gov't $	16%	47%	8%	7%

* Source: Based on 1995 sample of 1,071medium-sized north-central cities with MSW recycling programs consisting of: (1) residential curbside collection, (2) commercial collection, (3) drop-off facilities, and/or (4) recyclables processing facilities (Resources for the Future, Discussion Paper 02-35, June 2002, Table 2, p.17).

Curb = residential curbside collection
Comm = commercial collection
Drpoff = drop-off facilities
Proc = Recyclables processing

State MSW Landfill Disposal Bans (2000)

Material Category	Nr. states w/ban	% states
▪ Vehicle batteries	32	63%
▪ Whole tires	30	59%
▪ Yard trimmings	21	41%
▪ Motor oil	19	37%
▪ White goods	17	33%
▪ Other materials	12	24%

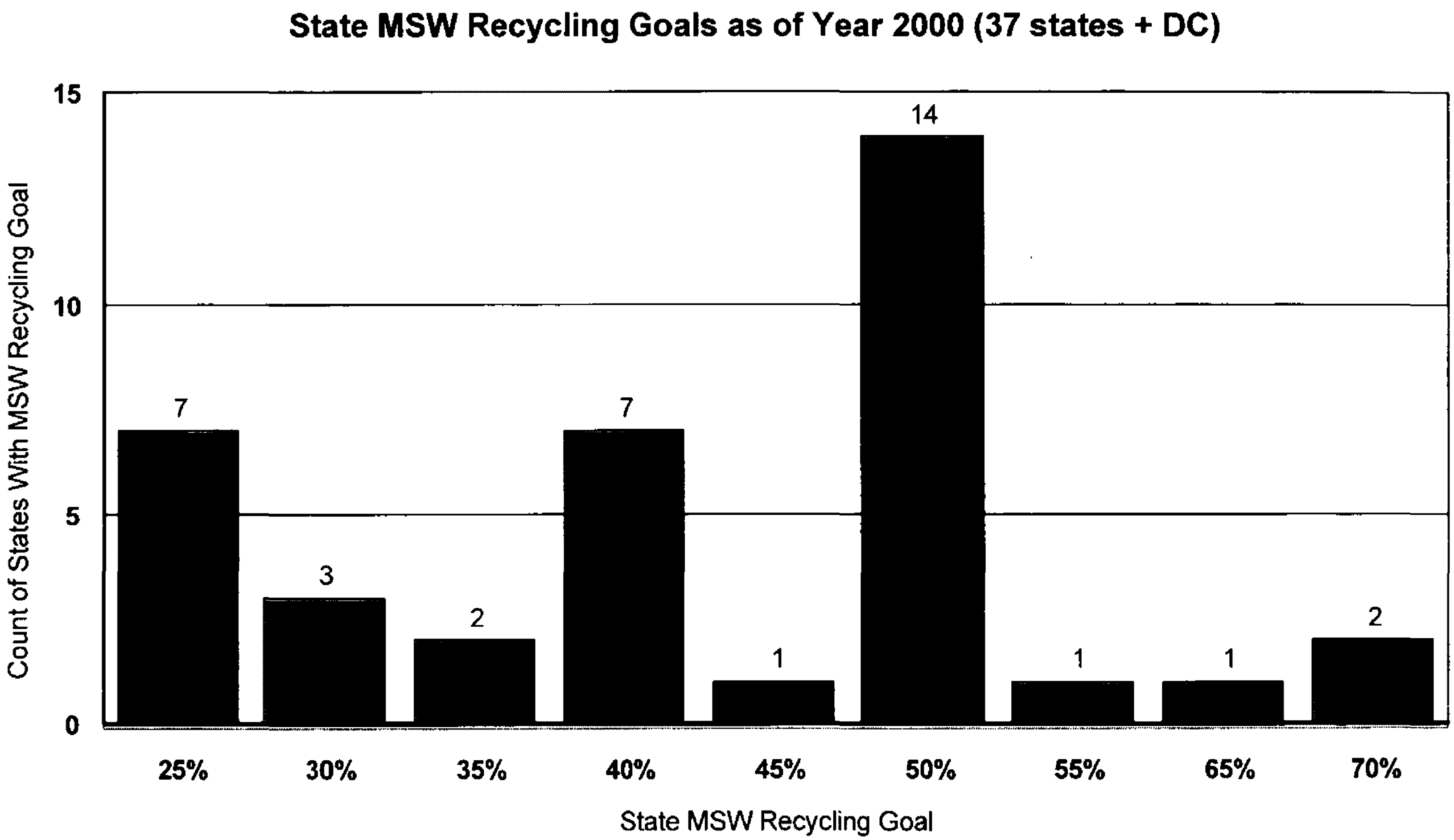
Source: BioCycle magazine, Dec 2001, Table 12, p.51 (40 states have at least one landfill ban; %'s above relative to 51 states + DC).

State MSW Recycling Goals (38 states w/goals)

70%	MA (2005)	RI (None*)		
65%	NJ (2000*)			
55%	ME (2003)			
50%	CA (2000*)	HI (2000)	IN (2001)	IA (2000)
	MN (1996)	NE (2002)	NM (2000)	NY (1997)
	OH (2005)	OR (2009*)	SD (2001)	VT (2005)
	WA (1995)	WV (2010)		
45%	DC (2000*)			
40%	CT (2000*)	MD (2005)	MO (1998)	NH (2000)
	NC (2001)	ND (2000)	TX (1994)	
35%	PA (2003)	SC (2005*)		
30%	DE (None)	FL (1994*)	KY (2010)	
25%	AL (None)	LA (1992)	MI (2005)	MS (1996)
	NV (None)	TN (2003*)	VA (2000*)	

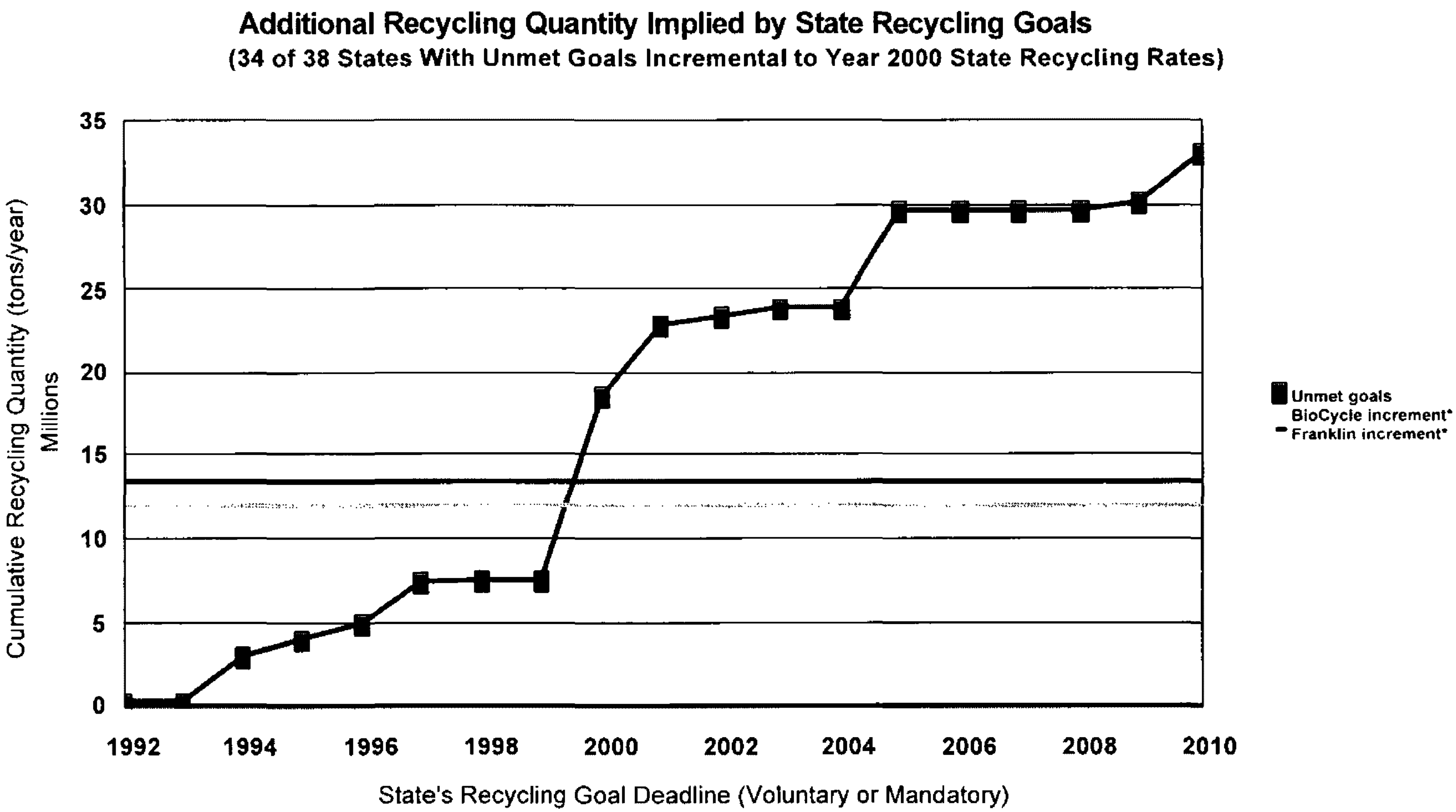
Source: BioCycle magazine, Dec 2001, Table 14, p.54 (data represent year 2000 state recycling policies).
Year in parenthesis indicates goal deadline. * Indicates mandatory goal (10 of 38 states with goals).

Summary of State MSW Recycling Goals



Source: BioCycle magazine, Dec 2001, Table 14, page 54.

Unmet State MSW Recycling Rate Goals



Source: Based on state MSW recycling goals from BioCycle magazine, Dec 2001, Table 14, p.54, benchmarked to year 2000 actual recycling rate & recycled waste quantity (tons).
* Incremental annual MSW quantity needed to increase national average from 30% (2000) to 35%.

Regional Summary of <35% Recycling Rate States

EPA Region	Nr.states	Nr.<35%	%lagging
■ **I (Boston)**	**6**	**4**	**67%**
■ II (NYC)	4	0	0%
■ III (Phil.)	6	3	50%
■ **IV (Atlanta)**	**8**	**7**	**88%**
■ V (Chicago)	6	3	50%
■ VI (Dallas)	5	3	60%
■ VII (Kansas C.)	4	2	50%
■ **VIII (Denver)**	**6**	**4**	**67%**
■ IX (San Fran.)	6	2	33%
■ X (Seattle)	4	1	25%
Totals =	55	29*	53% to 64%*

* Based on BioCycle 2000 recycling rate data for 45 states.

2A.2
City MSW Recycling Rates

MSW Recycling Rates for 25 Most Populous US Municipalities (2001/2002)

	R+C	R	C		R+C	R	C
1. San Francisco	48.0%	38.0%	56.0%	14. Phoenix	NA	21.0%	NA
2. Chicago	NA	44.3%	NA	15. Wash DC	NA	18.2%	NA
3. San Diego	44.0%	NA	NA	16. Columbus	NA	13.0%	NA
4. San Jose	42.0%	NA	NA	17. Boston	NA	13.0%	NA
5. Los Angeles	NA	39.0%	NA	18. Indianapolis	NA	11.8%	NA
6. Philadelphia	38.5%	5.5%	NA	19. San Antonio	NA	10.1%	NA
7. Seattle	37.9%	48.5%	36.7%	20. Detroit	NA	7.2%	NA
8. New York	35.7%	19.8%	44.0%	21. Nashville	7.0%	8.0%	NA
9. Jacksonville	33.0%	35.0%	43.0%	22. Houston	NA	7.0%	NA
10. Austin	NA	29.5%	NA	23. Denver	NA	6.7%	NA
11. Baltimore	28.7%	NA	NA	24. El Paso	2.5%	NA	NA
12. Milwaukee	NA	26.8%	NA	25. Dallas	NA	2.2%	NA
13. Memphis	NA	25.6%	NA				

Source: Waste News, 17 Feb 2003.
NA = not available.

R = residential recycling rate
C = commercial recycling rate

Regional Summary of <35% Recycling Rate For 25 Most Populous Municipalities

EPA Region	Nr.cities	Nr.<35%	%lagging
I (Boston)	**1**	**1**	**100%**
II (NYC)	1	0	0%
III (Phil.)	3	2	67%
IV (Atlanta)	**4**	**3**	**75%**
V (Chicago)	**5**	**4**	**80%**
VI (Dallas)	**4**	**4**	**100%**
VII (Kansas C.)	0	0	NR
VIII (Denver)	**1**	**1**	**100%**
IX (San Fran.)	5	1	20%
X (Seattle)	1	0	0%
Totals =	25	16	64%

2A.3
Materials Recycled

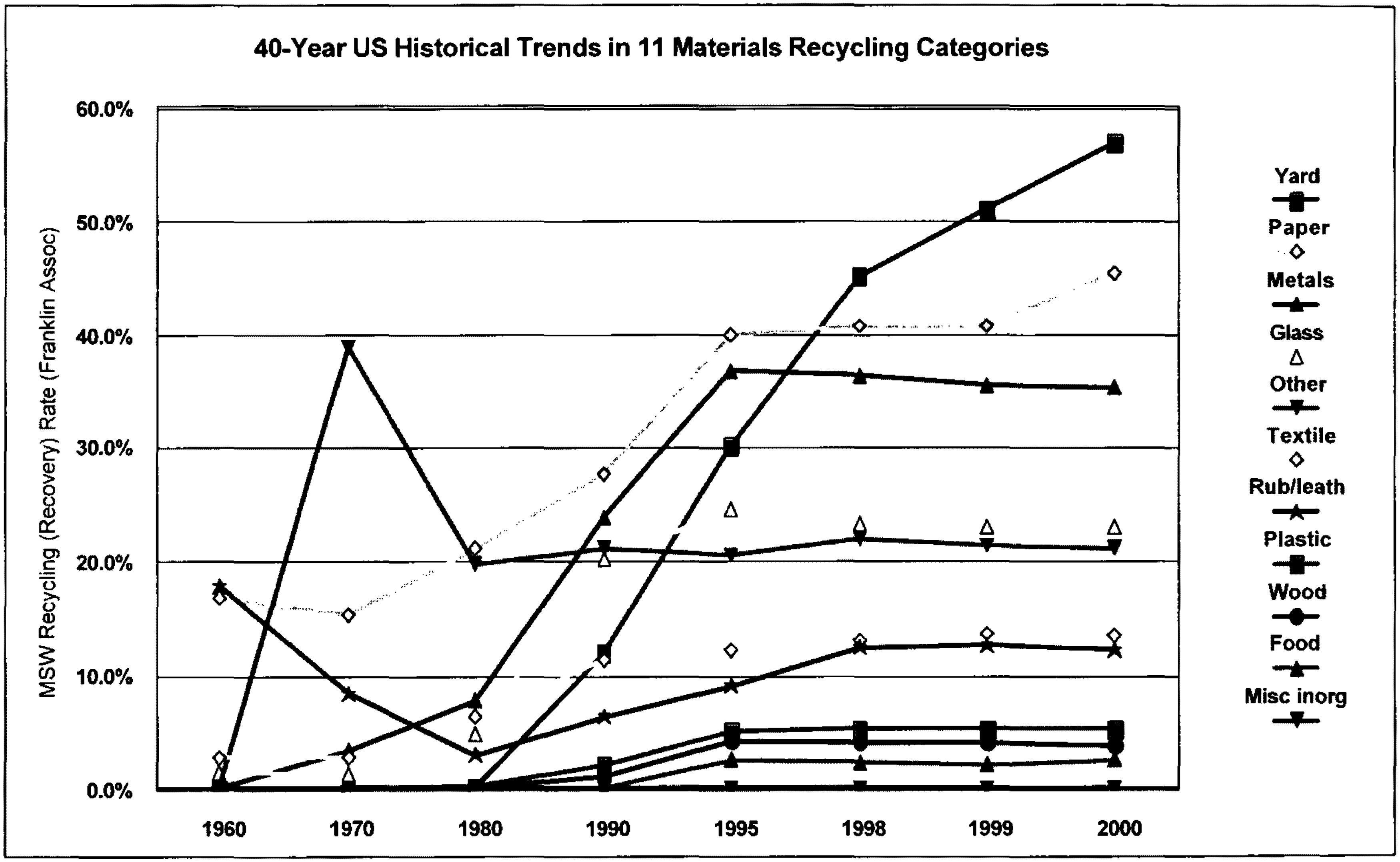
Baseline Materials Recycled (2000)

2000 Generation (million tons)	
1. Paper & paperboard	86.7
2. Yard trimmings	27.7
3. Food	25.9
4. Plastics	24.7
5. Metals	18.0
6. Glass	12.8
7. Wood	12.7
8. Textiles	9.4
9. Rubber & leather	6.4
10. Other materials NEC	4.0
11. Misc inorganic wastes	3.5
Total =	231.9

Recovery as % of Generation	
1. Yard trimmings	56.9%
2. Paper & paperboard	45.4%
3. Metals	35.4%
4. Glass	23.0%
5. Other materials NEC	21.3%
6. Textiles	13.5%
7. Rubber & leather	12.2%
8. Plastics	5.4%
9. Wood	3.8%
10. Food	2.6%
11. Misc inorganic wastes	0.05%
Total =	**30.1%**

Source: Franklin Assoc. (EPA-530-R-02-001), Table ES-4, page 7.

Historical Trends in Materials Recycling Categories



2A.4
Recent Policy Decisions and Future Policy Options for Affecting MSW Recycling Rates

Examples of Recent Developments Which May <u>Increase</u> the Near-Future MSW Recycling Rate

Recycling (Materials) Supply Factors:

- In 2002, the Metropolitan Gov't of Nashville & Davidson County implemented a single-stream curbside recycling program to raise the city's 8% recycling rate to 25% by 2004.
- In 2003, Seattle Public Utilities launched a program to increase multi-family recycling from 22% (2001) to 37% in 2008.
- NY enacted a law May 2003 to clean-up scrap tires & encourage markets for recycling, and created a fee ($2.5 per new tire sold) to fund tire recycling.

Recycling (Materials) Demand Factors:

- In 2003, Waste Management Inc formed the new recycling organization "Recycle America Alliance" (http://www.recycleamericaalliance.com), to combine assets and operations with other domestic recycling processors and marketers; WMI's first partner is The Peltz Group (Milwaukee WI), the largest privately owned US recycler.
- The US paper industry (AF&PA) decided in 2002 to boost the recovered fiber recycling rate from 48% (current) to 55% in 2012, by collecting more used paper from offices and schools.
- Starting in 1999, Albertson's US grocery chain (2,300 stores) is pushing its suppliers to use non-waxcoated boxes to boost box recycling beyond 85%.
- In 2003 the California State Senate Appropriations Committee approved a bill that would require electronics manufacturers to develop and finance a free and convenient system to recycle end-of-life electronics. As of May 2003, 26 states introduced 52 bills on electronics recycling, according to State Recycling Laws Update from Raymond Communications, Inc. (http://www.raymond.com/state/).
- In June 2003 the New York State Assembly passed a bill (147-0) requiring the recycling of wireless phones.
- Waste Management Inc. decided in 2003 to open a second plastic bottle recycling facility in Chicago in 2004 that will handle 100 million pounds of plastic a year, duplicating a plant in North Carolina that started operating early last year.

- China's demand for US exports of recovered paper fiber projected to grow from 1 million (1995) to 6 million tons (2003)

Examples of Recent Developments Which May Decrease the Near-Future National MSW Recycling Rate

Recycling (Materials) Supply Factors:

- The year 2002 "Green Gauge" survey reported that the biggest drop in American's participation in environmentally-friendly activities is for recycling: 45% regularly return bottles to a store or recycling center, and 36% take part in a curbside recycling program, down 6 and 9 points respectively from 2001.

- Iowa state legislature voted in 2003 to remove a landfill ban on yard waste (http://www.wastenews.com/headlines2.html?id=1054241503); but on 12 June 2003, Iowa Gov. Tom Vilsak vetoed this legislation. "Bans on disposal of yard trimmings in landfills have made it possible to essentially double the overall diversion rate and are absolutely vital to achieving America's recycling goals, which is why 21 other states have also enacted laws banning disposal of yard trimmings," said Neil Seldman, president of the Institute for Local Self-Reliance.

- Since the mid-1980s, the popularity of cell phones has soared from 340,000 people in the US owning cell phones, to 130 million cell phones — complete with batteries and chargers — will be pitched each year by 2005, adding an annual 65,000 tons of garbage to the nation's solid waste stream, mostly for landfilling and incineration.

- The aluminum can US recycling rate has dropped for the 5th straight year from 67% (1997) to 53% (2002).

Recycling (Materials) Demand Factors:

- MA launched a recycling center at Univ of MA in 1995 to stimulate manufacturers' use of recycled materials, but is closing it June 2003 due to lack of continued funding.

Policy Options for Stimulating Recycling Implied From Baseline Data

- Target attention/assistance to major municipalities:
  - Up to 16 of 25 most populous cities <35% goal (R+C)
- Target attention/assistance to states:
  - Up to 29 of 45 states <35% goal
  - At least 20 states <53% state population coverage national average
- Target attention/assistance to EPA Regions:
  - Regions I, IV, VIII >65% average lag for states under jurisdiction
  - Regions I, IV, V, VI, VIII >65% average lag for top-25 municipalities within jurisdiction
- Target materials recycling categories:
  - 8 of 11 materials <35% goal
  - Metals, glass, & rubber/leather recycling rates declining since 1998
  - Plastics, wood, and food <5% recycling rates.
- Facilitate/expand municipal & state recycling initiatives:
  - Promote initiatives/programs in other jurisdictions (e.g. single-stream pickup, schools, multi-family apts, grocery stores, electronics)
  - Implement national guidance or national RCRA legislation (e.g. yard waste landfill bans only in 23 states as of 1997).

2B. MSW Recycling Infrastructure

2B.1 Statewide Population Coverage

2B.2 Urban & Rural Penetration

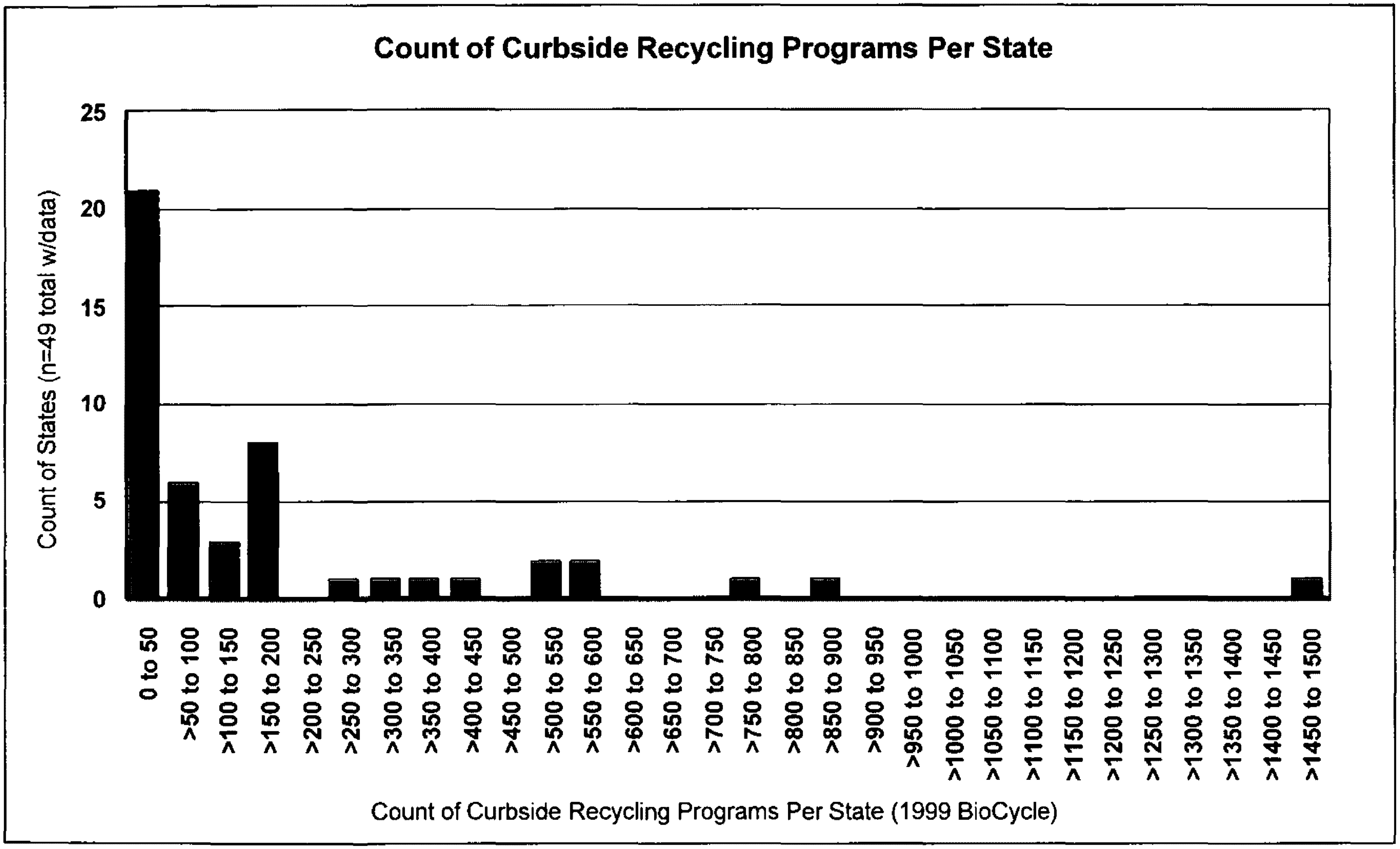
2B.3 Comparison of Recycling Rates & Infrastructure

Overview of MSW Recycling Infrastructure

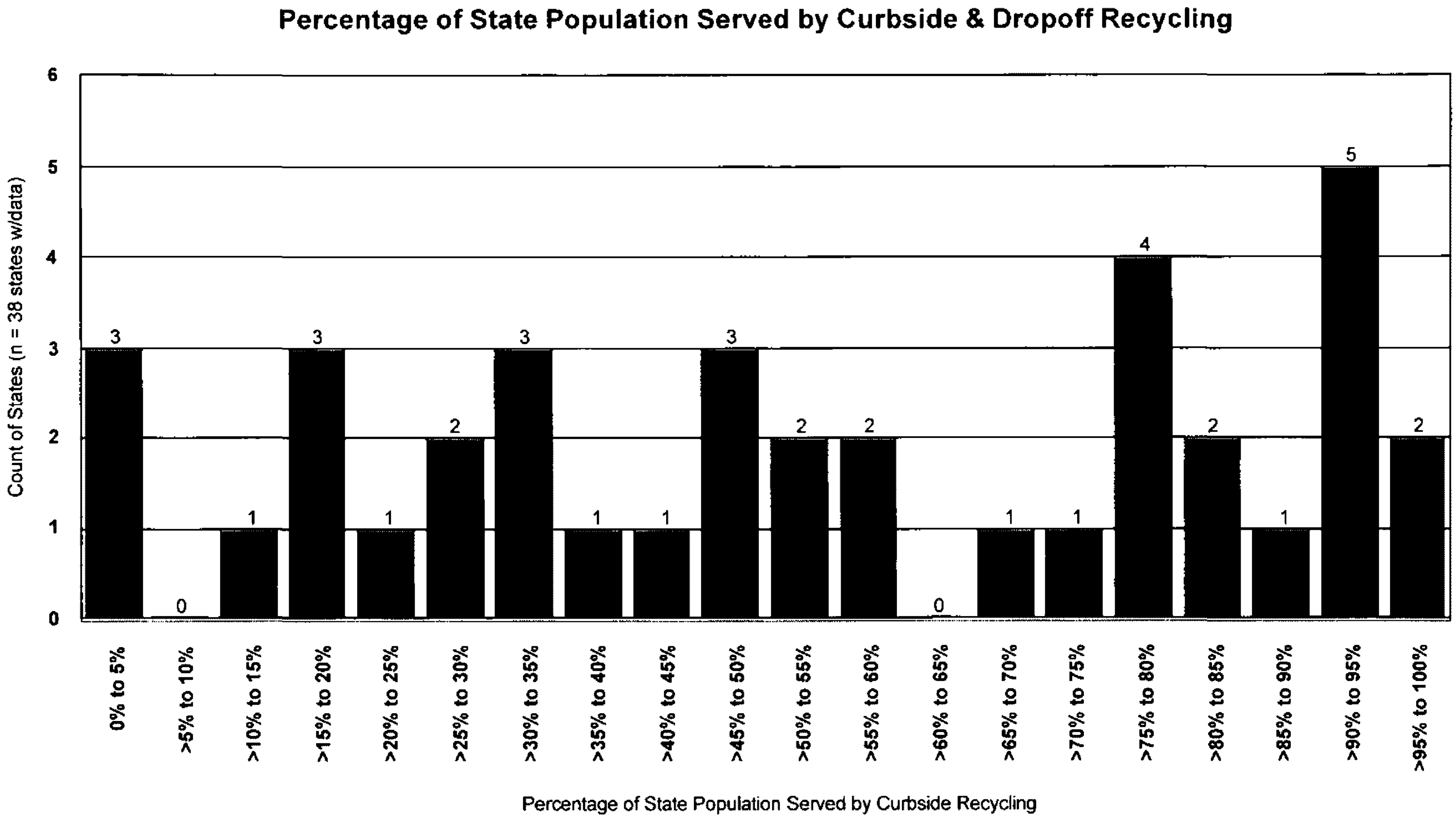
- In 1997 51% of US population had access to curbside recycling programs.
- In 2000 there were 9,250 curbside recycling programs (represents a 39% maximum coverage for 23,435 total US municipalities; aka Census "places").
- In 1997 there were 12,700 drop-off centers for recyclables, compared to 23,435 total 1990 municipalities in the US (represents a 54% maximum coverage).
- National ratio of communities (and tonnage) with curbside:to:drop-off recycling = 90%:to:10%
- In 1997 there were 1,540 solid waste collection/hauling establishments selling recyclable materials ($414 million receipts; NAICS code=562111, NAICS RL code=4450).
- Waste/scrap shipped an average of 164 miles in 1997.
- In 1997 there were 765 establishments involved in sorting MSW recyclable materials ($1.3 billion receipts, 10,900 employees; NAICS=562920).
- 30 states reported annual state government budgets for recycling (including composting) totaling $173 million in 2000 (PA leads at $6.17/year per resident).
- Of the 25 most populous cities, San Diego leads municipal government recycling budgets at $15.04/year per resident.
- 38 states have recycling goals: 26 states have set state-wide recycling goals >35% for achievement by 1994 (TX) to 2010 (MA & WV); 12 states set recycling goals <35%.

2B.1
MSW Recycling Infrastructure:
Statewide Population Coverage (2000)

Number of Curbside Recycling Programs Per State



MSW Recycling Services: State Population Coverage



Source: OSW estimate based on curbside recycing population coverage from BioCycle magazine, Dec 2001, Table 6, p.47, supplemented with additional 10% dropoff assumption.

State Population Coverage Statistics (prior graph)

1. CT 100%
2. NJ 99.0%
3. RI 94.3%
4. CA 92.0%
5. NY 90.8%
6. WA 90.2%
7. NV 90.2%
8. OR 85.5%
9. MA 84.6%
10. MN 83.6%
11. PA 79.6%
12. IN 76.2%
13. MD 75.5%
14. IA 75.3%
15. IL 72.0%
16. WI 65.7%
17. VT 59.3%
18. FL 59.1%
19. AZ 52.6%
20. KS 50.5%
21. NC 48.3%
22. SC 46.4%
23. NH 45.9%
24. ME 42.4%
25. HI 36.7%
26. OK 34.0%
27. MI 33.0%
28. NE 32.5%
29. AL 27.5%
30. TX 26.6%
31. NM 24.4%
32. VA 18.0%
33. ND 17.3%
34. KY 16.2%
35. MS 12.7%
36. WY 4.5%
37. DE <1%
38. AK 0%

Source: OSW estimate based on curbside recycling population served data from BioCycle magazine (Dec 2001, Table 6, p. 47), supplemented with additional 10% assumed dropoff recycling population served (per 90:to:10 overall national ratio); 13 states do not have data on population coverage.

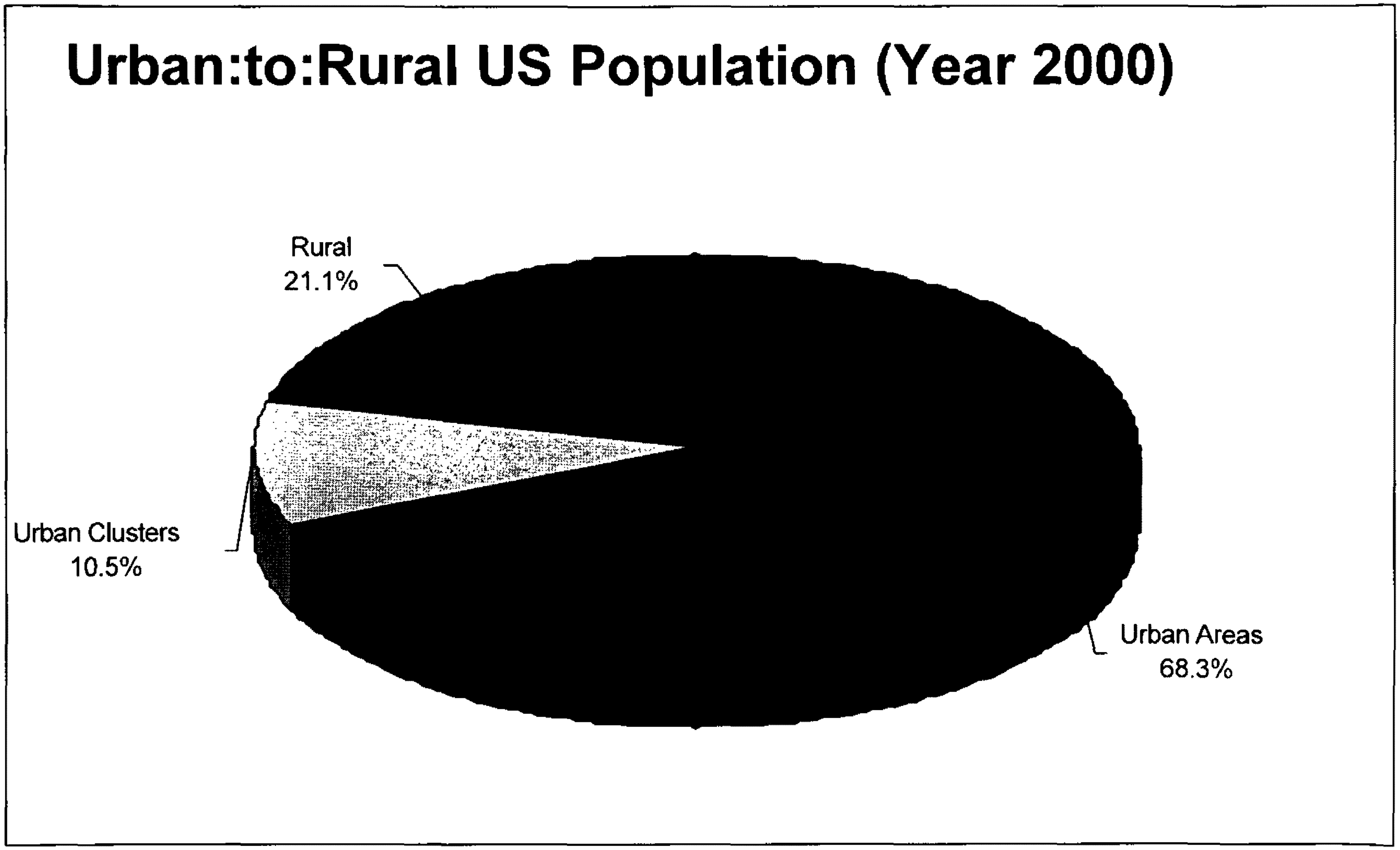
As of 2000, 13 States Lack Knowledge (Data) About Fraction of Population Served by Recycling Programs

- Arkansas (na)
- Colorado (n/a)
- DC (1)
- Georgia (459)
- Idaho (20)
- Louisiana (25)
- Missouri (177)
- Montana (na)
- Ohio (232)
- South Dakota (na)
- Tennessee (na)
- Utah (7)
- West Virginia (51)

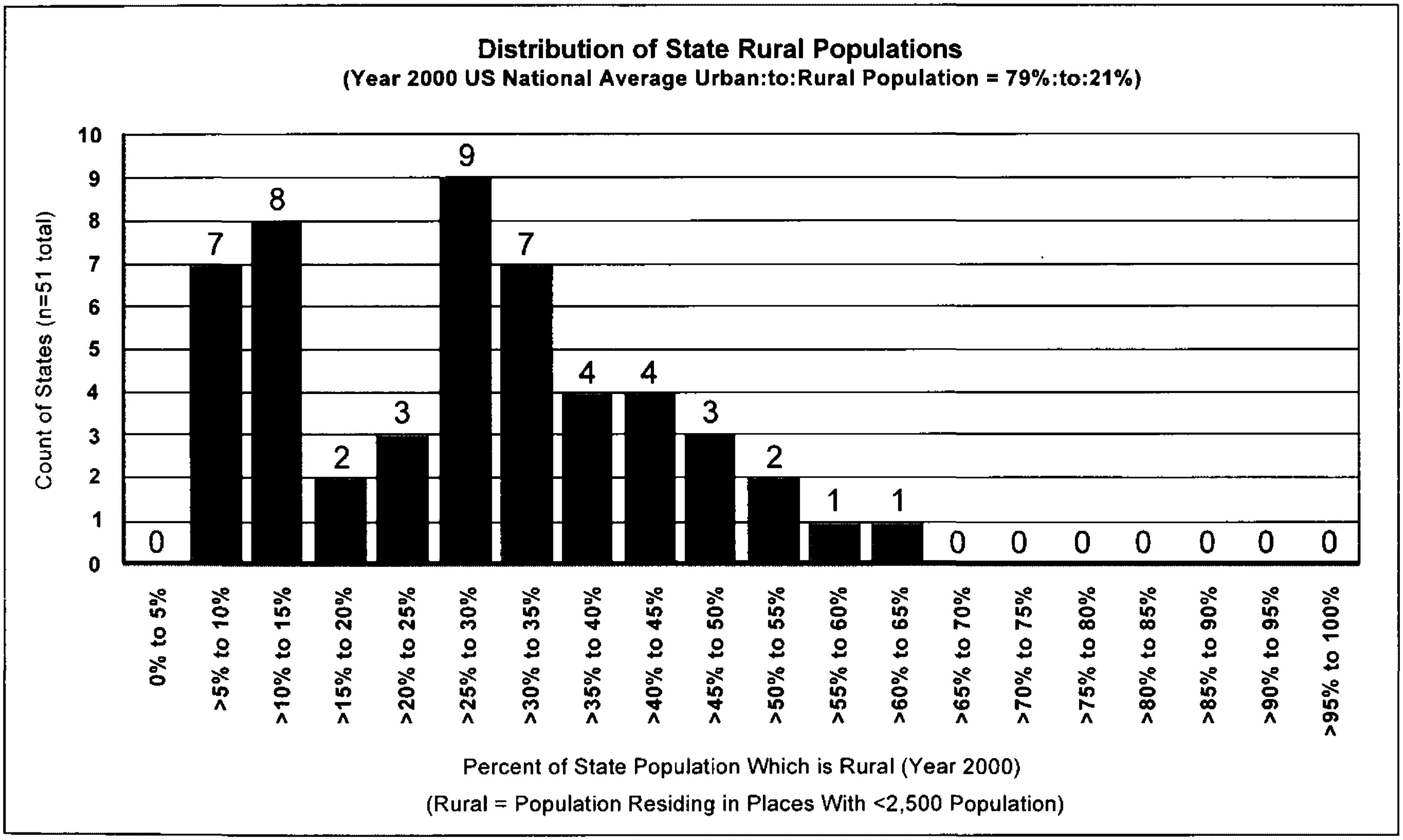
Numbers in parentheses indicate count of state curbside recycling programs (year 2000).
Source: BioCycle magazine, Dec 2001, Table 6, p.47
Na = data not available from state in 2001 survey.

2B.2
MSW Recycling Infrastructure: Urban & Rural Penetration (2000)

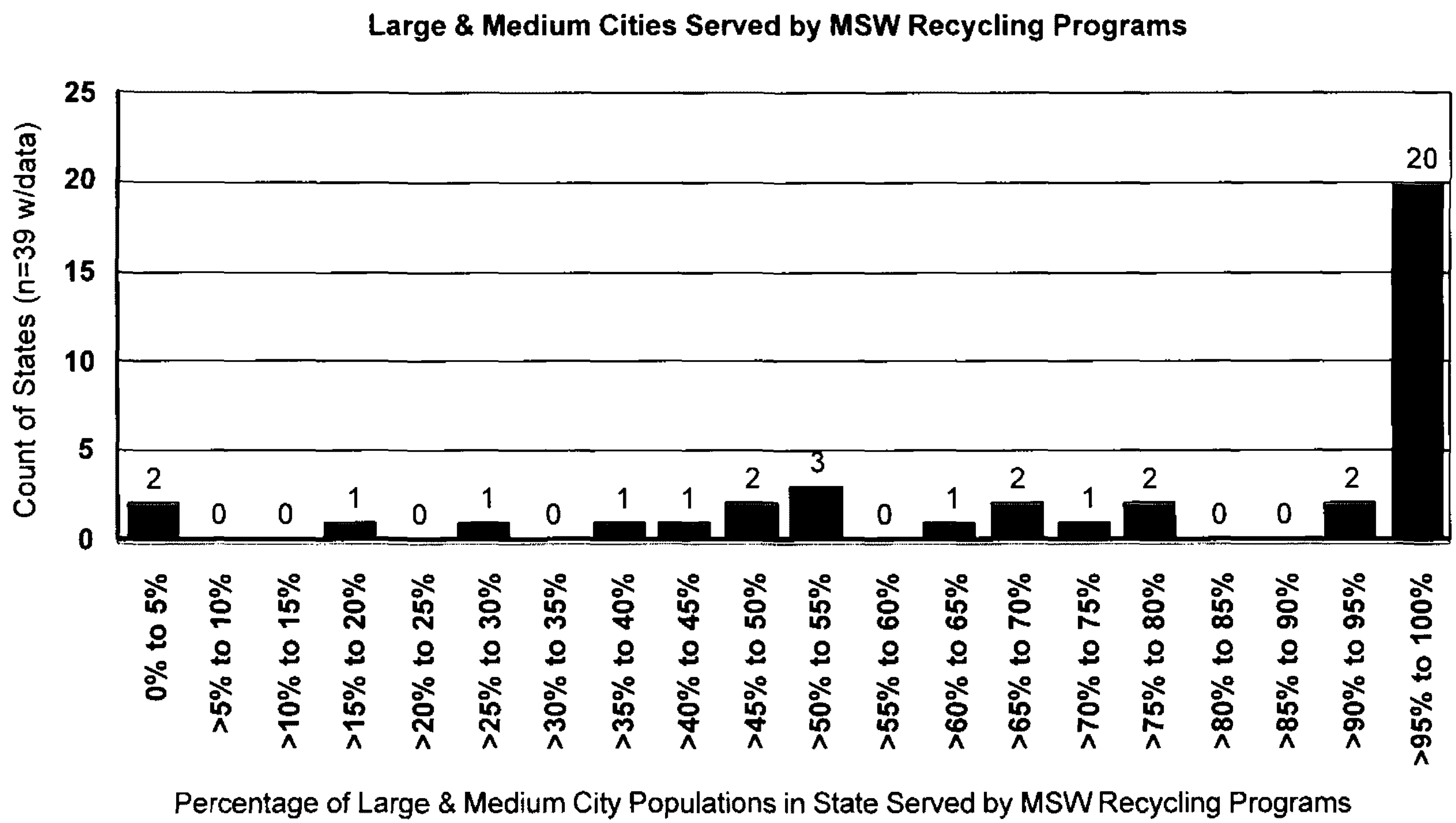
Urban:to:Rural US Population (Total = 281.4 million year 2000)



21% Rural Population: Economically-Beneficial MSW Recycling May Require Population Density to Avoid High Collection Costs

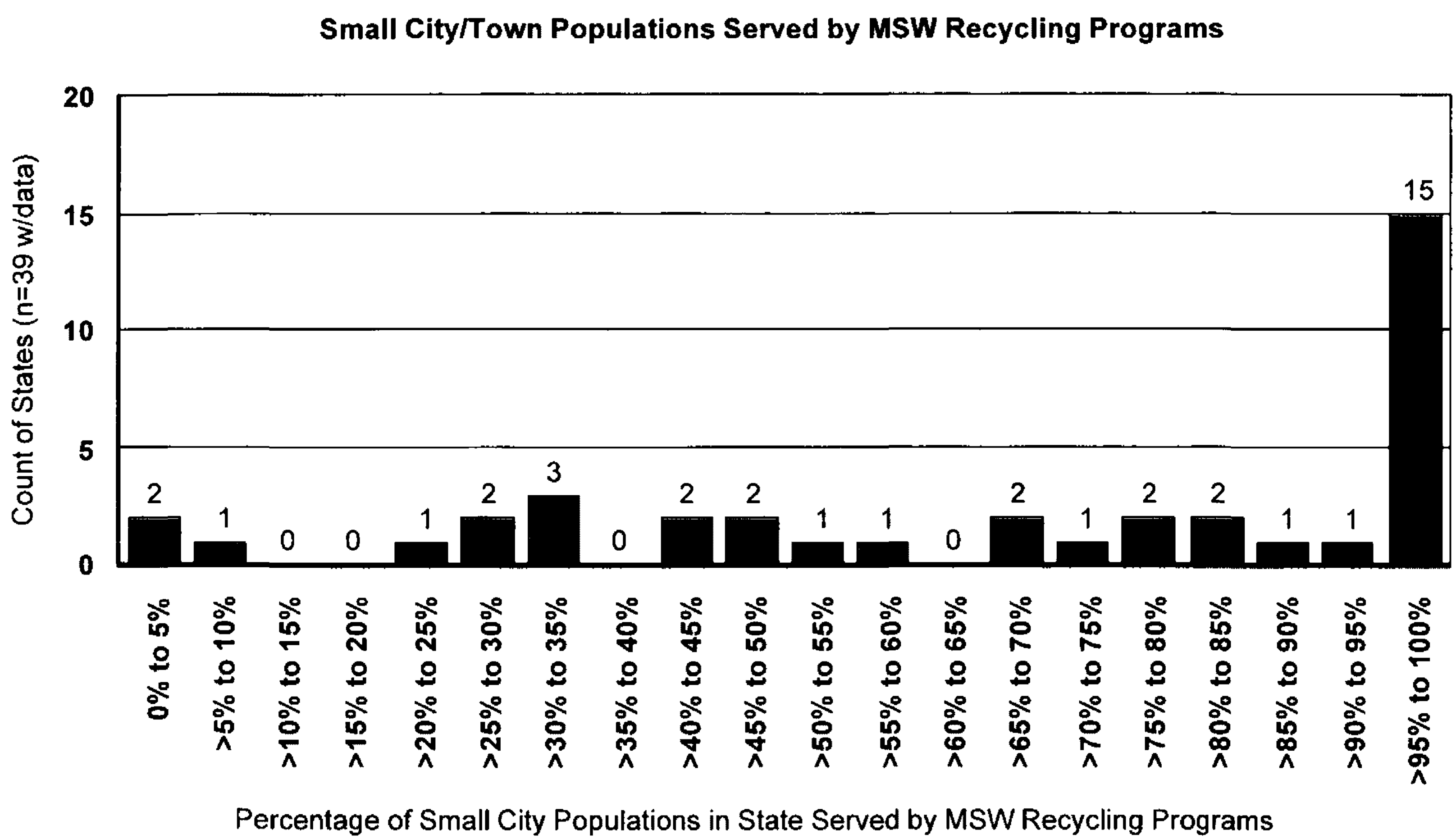


Large & Medium Cities ("Urban Areas" >50,000 Population) in State Served by MSW Recycling Programs (2000)



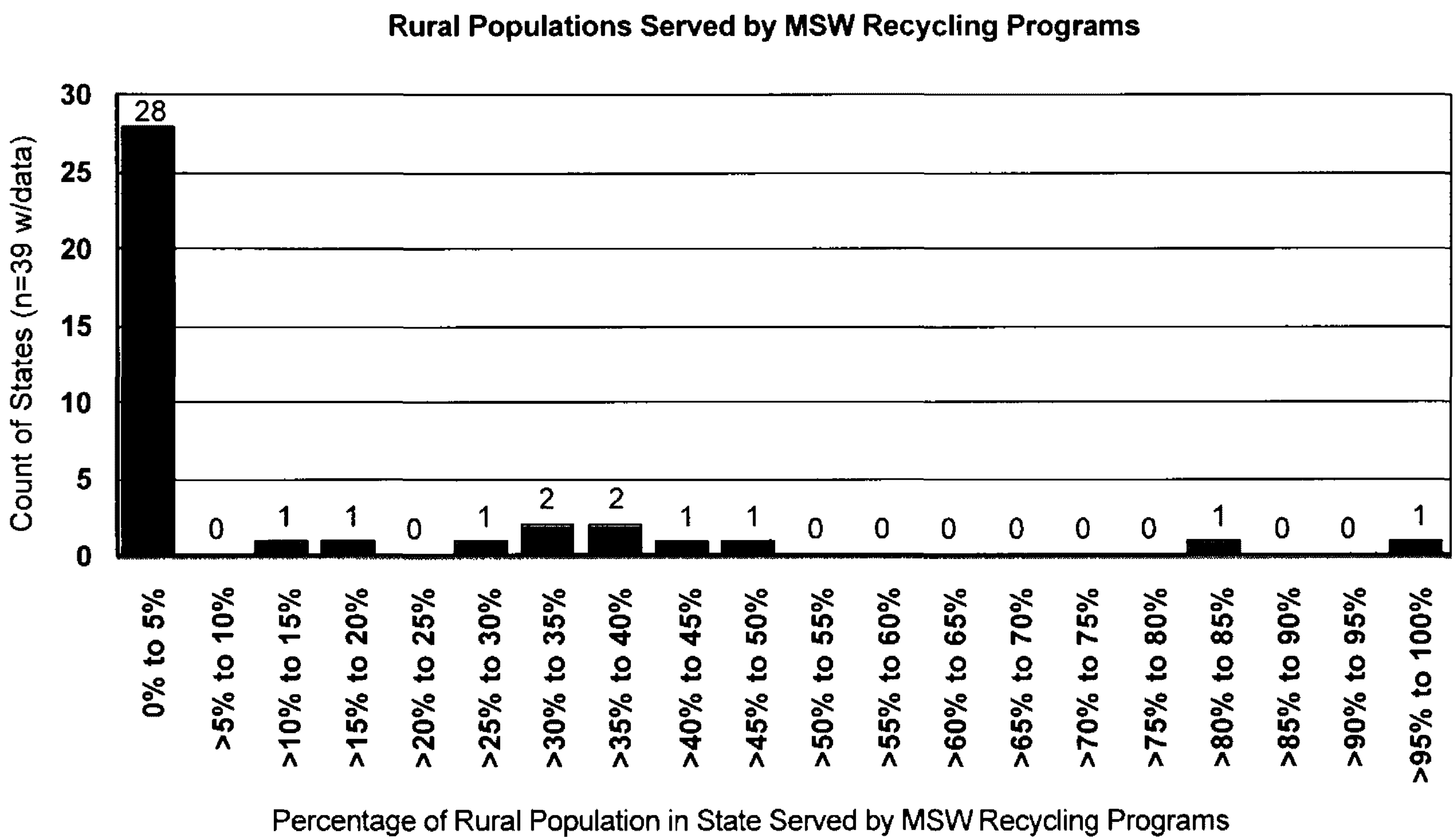
Source: Based on curbside population served from BioCycle magazine, Dec 2001, Table 6, p.47, supplemented by up to 10% dropoff estimate.

Small Cities/Towns ("Urban Clusters" 2,500 to 50,000 Population) Served in State by MSW Recycling Programs (2000)



Source: Based on curbside population served from BioCycle magazine, Dec 2001, Table 6, p.47, supplemented by up to 10% dropoff estimate.

Rural Areas (<2,500 Population) Served in State by MSW Recycling Programs (2000)



Source: Based on curbside population served from BioCycle magazine, Dec 2001, Table 6, p.47, supplemented by up to 10% dropoff estimate.

2B.3

Exploratory Statistical Comparisons of Statewide & City MSW Recycling Rates & Recycling Infrastructure (see graphs in Appendices)

The following are the apparent strongest statistical (X-Y plot) associations exhibited for possible drivers behind MSW recycling rates & costs (negative sign indicates inverse association; % is trendline fit to data displayed in Appendices)

- State Recycling Infrastructure Comparisons (based on 1 data set):
  - 51%: Recycling rate compared to state count of incorporated places divided by state count of recycling programs (-)
  - 35% Recycling rate compared to state recycling budget per capita (+)
  - 35%: Recycling rate compared to state land area divided by state count of recycling programs (-)
  - 34%: Recycling rate compared to state population divided by state count recycling programs (-)

- Municipality Recycling Infrastructure Comparisons (based on 2 data sets):
  - 40%: Recycling cost ($/ton) compared to annual quantity MSW recycled by municipality (-)
  - 33%: Recycling cost ($/ton) compared to municipal population (+)
  - 21%: Recycling rate compared to municipal population density (per square mile) (+)
  - 19%: Recycling cost (&/ton) compared to municipal population density (-)
  - 19%: Recycling cost ($/ton) compared to municipal recycling rate (-)
  - 17%: Recycling rate compared to municipal gov't budget per-capita spending on recycling programs (+)
  - 15%: Recycling rate compared to percentage of municipal budget spent on recycling programs (+)

2C. Benefit-Cost Analysis of 35% Goal

2C.1 Recycling Costs
2C.2 Recycling Benefits
2C.3 Recycling Benefit-Cost Ratio (BCR)
2C.4 Recycling Impact on National Employment

2C.1
MSW Recycling Costs

MSW Recycling Cost Dataset (Drop-off Programs in 14 Cities, 1995)

DROP-OFF RECYCLING UNIT COSTS

Source: Table II-5, EPA-600-R-95-109, July 1995 (1993$)

* Total cost = annualized capital cost + O&M cost + education/admin cost

Case study	City	State	1990? population	Public or private	Annual tons collected	Total cost* net of revenues ($/ton)	O&M ($/ton)	O&M as % total cost	overhead ($/ton)	Recycled materials revenues ($/ton)
1	Santa Monica	CA	86,905	public	3,214.2	$73.83	$50.57	68.5%	$23.26	$0
2	Southeast	CO	111,727	private	1,324.0	$71.73	$68.71	95.8%	$3.02	$36.00
3	Largo	FL	38,400	public	2,040.0	$81.43	$23.16	28.4%	$58.27	$17.16
4	Tampa	FL	229,712	public	3,272.7	$95.24	$59.03	62.0%	$36.21	$0
5	Blue Ash	OH	13,629	private	701.0	$51.36	$25.68	50.0%	$25.68	$0
6	W.Greenwich	RI	2,749	private	156.0	$86.28	$73.46	85.1%	$12.82	$0
7	Falmouth	ME	7,610	private	338.0	$87.22	$67.49	77.4%	$19.73	$0
8	Freeport	ME	7,043	private	320.0	$155.30	$91.21	58.7%	$64.09	$23.99
9	Queen Village	PA	9,443	public	250.0	$60.00	$60.00	100.0%	$0	$0
10	Cedar Park	PA	13,461	public	202.0	$60.00	$60.00	100.0%	$0	$0
11	Chesterfield	VA	225,100	private	3,081.8	$41.35	$40.57	98.1%	$0.78	$4.94
12	Petersburg	VA	38,400	private	357.2	$36.59	$35.50	97.0%	$1.09	$4.22
13	Henrico	VA	230,000	private	3,402.8	$41.36	$33.95	82.1%	$7.40	$7.71
14	Norfolk	VA	261,229	public	982.8	$86.00	$80.75	93.9%	$5.25	$4.13
		Min =	2,749			$36.59	$23.16	28.4%	$0.00	$4.13
		Max =	261,229			$155.30	$91.21	100.0%	$64.09	$36.00
		Mean =	91,101			$73.41	$55.01	78.4%	$18.40	$14.02
		Median =	38,400			$72.78	$59.52	83.6%	$10.11	$7.71
					Std.dev=	$30.41	$20.85	22.1%	$21.34	$11.08
					Tons-wtd avg =	$67.79	$47.61	74.1%	$20.18	
					Skewness =	1.24				
					-68% conf. =	$43.00				
					+68% conf. =	$103.82				
					Updated to year 2002$:					
					Min =	**$44.25**				**$4.99**
					Max =	**$187.80**				**$43.53**
					Mean =	$88.77				$16.96
					Median =	$88.01				$9.32
					Std.dev=	$36.77				$13.40
					Tons-wtd avg =	$81.98				
					Skewness =	$1.50				
					-68% conf. =	**$52.00**				
					+68% conf. =	***$125.54***				

MSW Recycling Cost Dataset (Curbside) Compared to Garbage Collection Costs

CURBSIDE COLLECTION RECYCLING UNIT COSTS

Source: Table 3, page 26, EPA-530-R-01-018, Nov 2001 (2000$)

Unit costs based on "full cost accouting" method, including transportation + fringe

	2001 Nat'l Proportion	Min	Mean	Max	Skewed interval method -68% conf.	+68% conf.
Multi-family	24%	$62	$177	$622	$120	$400
Single-family	76%	$11	$127	$420	$69	$274
	Weighted =	$23	$139	$468	$81	$304
	Updated (2002$) =		$142		$83	$311

Price decline for single-family curbside recycling:

Year	$/ton
1993	$170
2000	$127
Average annual rate =	-4.08%

REFUSE (GARBAGE) COLLECTION UNIT COSTS

Source: Table 3, page 26, EPA-530-R-01-018, Nov 2001 (2000$)

	2001 Nat'l Proportion	Min	Mean	Max	Skewed interval method -68% conf.	+68% conf.
Multi-family	24%	$16	$63	$171	$40	$117
Single-family	76%	$16	$69	$286	$43	$178
	Weighted =	$16	$68	$259	$42	$163
	Updated (2002$) =		$69		$43	$167

ENR Building cost index update factor (2002/2000) = 1.024

MSW Recycling Direct Cost Compared to Two Cost Offsets

Direct costs for operating recycling programs usually exceed cost offsets:

Cost Offset Example #1(40 cities, 2002$):	-1SD	Mean	+1SD
▪ Recycling program net cost* ($/ton)	$83	$142	$311
▪ Avoided garbage collection cost offset* ($/ton):	$43	$69	$167
▪ Avoided garbage disposal cost offset** ($/ton):	$30	$36	$58
Total cost offset ($/ton) =	$73	$105	$225
Recycling net cost w/offset ($/ton) =	$10	$37	$86
Offset as % of recycling cost =	88%	74%	72%

Cost Offset Example #2 (30 cities, 2002$):			
Recycling program total cost*** ($/ton)	$4	$64	$124
▪ Offset value of recyclable materials*** ($/ton):	<$0.1	$10	$44
Recycling net cost w/offset ($/ton) =	$3	$54	$80
Offset as percentage of recycling cost =	<1%	16%	35%

Data Sources & Notes (SD = standard deviation):

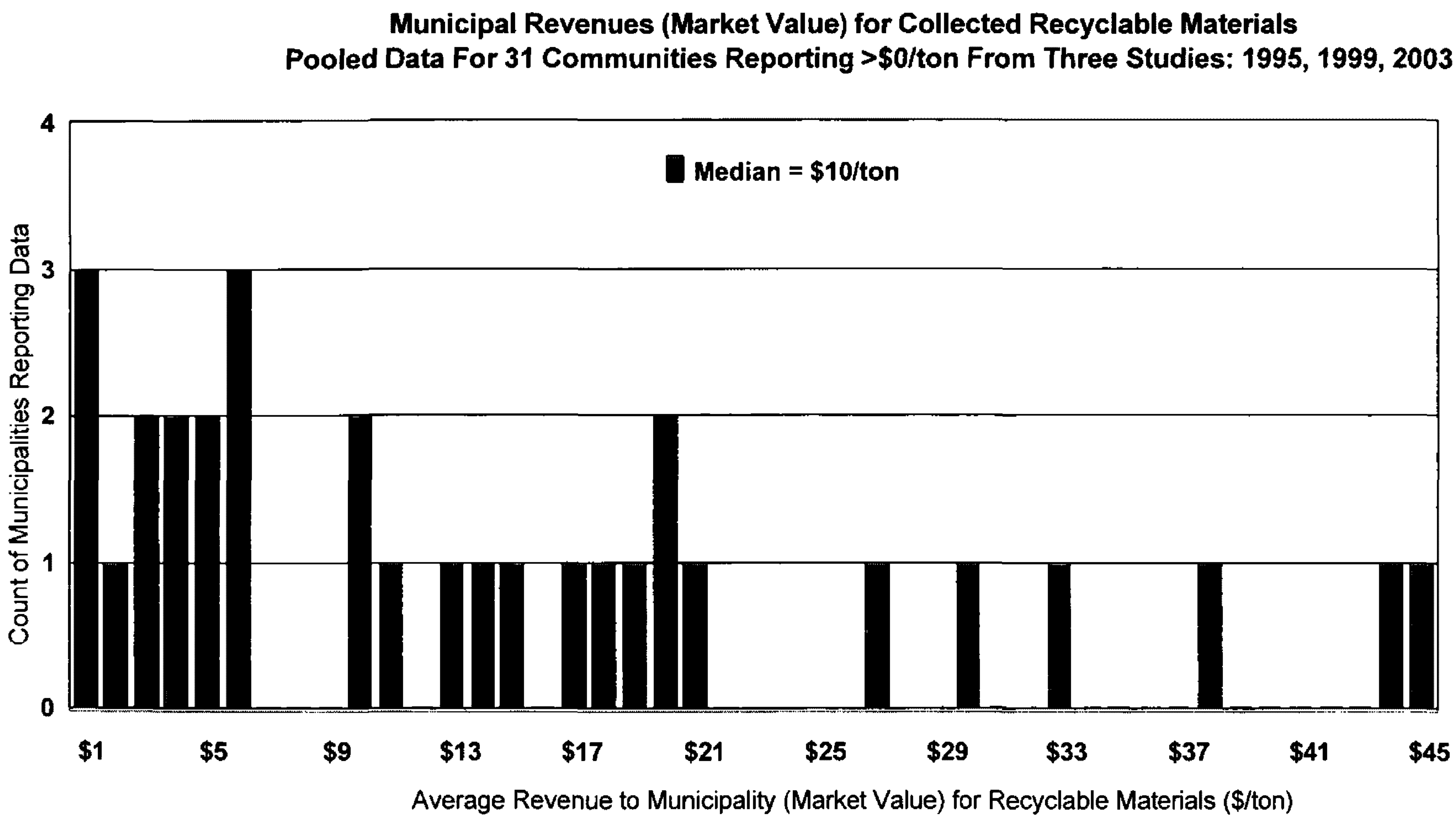
* EPA-530-R-01-018, Nov 2001, Table 3, p.26; based on data ranges for 40 communities ranging from 28,000 to 8.0 million population (median = 70,000); net cost = cost to local government, minus any recycled material revenues.

** Year 2002 landfill tipping fees from http://wasteinfo.com/data.htm (LB = landfills; ML= wtd avg if 55.3% landfill + 14.5% combust; UB= combust).

*** Based on pooled data points for 31 communities ranging from 1,900 to 6.0 million population, from three reports (EPA-600-R-95-109 July 1995, EPA-530-R-99-013 June 1999, & Waste News magazine17 Feb 2003) for curbside and dropoff recycling programs; normalized by OSW to 2002$ (Mid = median).

- Collection transportation (hauling) reportedly constitutes 39% to 62% of total annualized cost.
- On average, capital investment reportedly represents 22% and annual O&M 78%, of total annualized cost.
- Single-family household curbside recycling costs have declined an average of 4.1% per year between 1993 & 2000.

Market Value of Pre-Processed Recyclable Materials Collected ($/ton)



Sources: (a) EPA-600-R-95-109 July 1995; (b) EPA-530-R-99-013 June 1999; (c) Waste News magazine 17 Feb 2003; all data normalized to 2002$

US Market Values for Pre-Processed Recyclable Materials ($/ton, July 2003)

Type of Recyclable Material	Low	Avg	High
▪ Metals			
▫ Steel (cans, white goods)	$10*	$33*	$51*
▫ Aluminum	$25	$31	$40
▪ Glass			
▫ Flint	$15	$24	$33
▫ Amber	$5	$16	$30
▫ Green	($20)	($2)	$5
▪ Plastics			
▫ PET	$10	$12	$18
▫ Natural HDPE	$15	$17	$17
▫ Colored HDPE	$8	$12	$13
▪ Paper (baled mixed)	$31**	$35	$46**

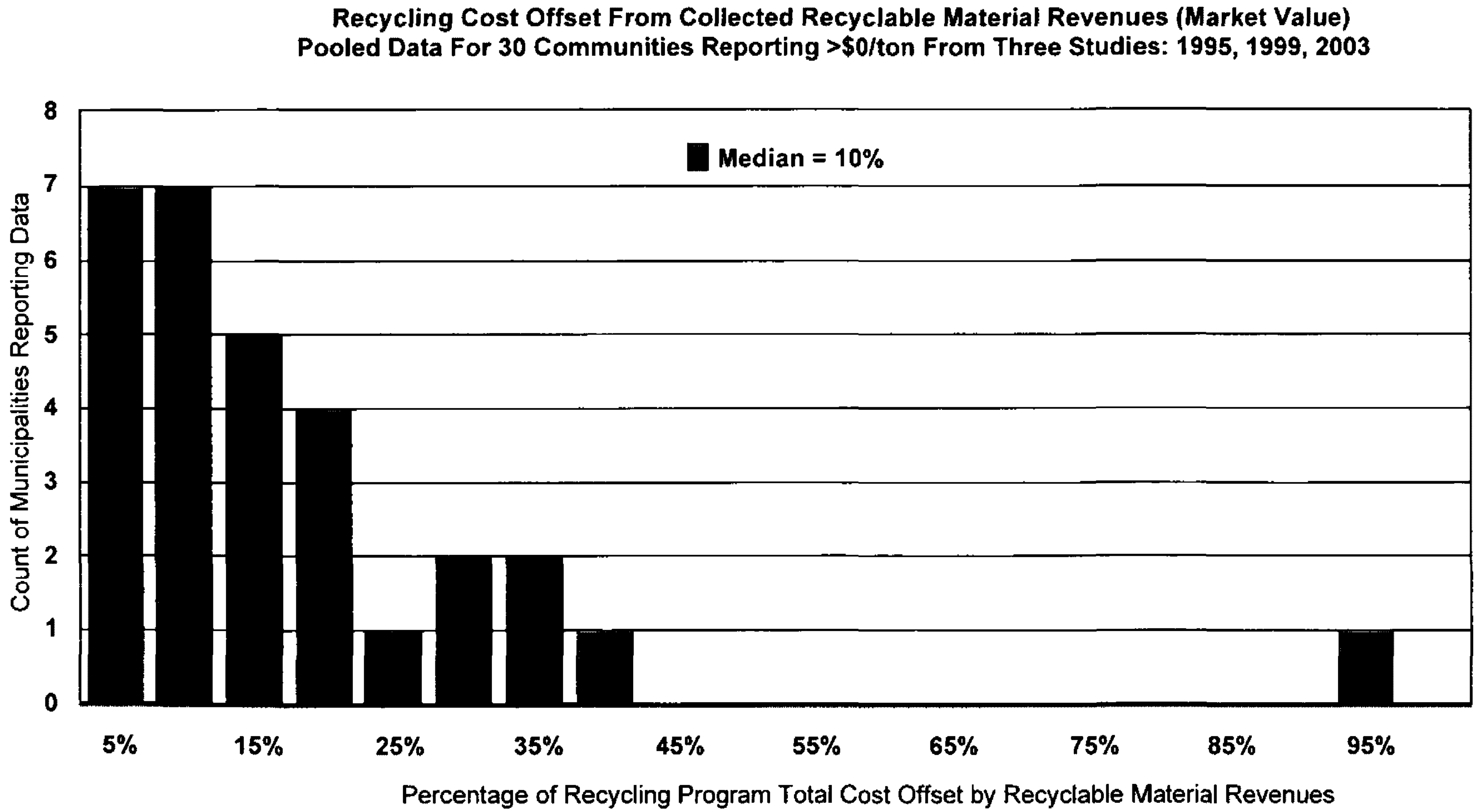
Source: Based on delivered price data for five US cities (New York, Atlanta, Chicago, Houston, Los Angeles) reported in Waste News magazine, 07 & 21 July 2003.

* In comparison, one of the US largest metal recyclers (Metal Management Inc, Chicago) reported $142/ton average selling price for post-processed recycled ferrous metals in first quarter of 2003 (Waste News, 12 Aug 2003). Other metal prices (scrap & virgin) are available at http://www.metalprices.com

**Low and high paper prices represent range over first seven months in 2003.

Parenthesis indicate negative price (i.e. payment to recovery facility to take recyclable materials).

Recycling Cost Offset From Recyclable Material Revenues



Sources: (a) EPA-600-R-95-109 July 1995; (b) EPA-530-R-99-013 June 1999; (c) Waste News magazine 17 Feb 2003.

National Annual Direct Cost of Achieving 35% Goal

- Incremental Tonnage: **12.0 million tons/year** additional recycling needed to achieve 35% (average of Franklin & BioCycle increments calculated relative to 2000 baseline).

- Unit Cost for Recycling (30 cities; 2002%):
  - Recycling collection: data sample* mix of curbside & dropoff programs ranges from $4 LB to $124 UB per ton (median = **$64/ton**) Note: this excludes societal cost for (a) household waste sorting time, (b) household container/space cost, & (c) household travel costs to recycling drop-off locations.
  - Recycling processing: Cost for processing collected recyclable material at an MRF (material recovery facility) = $14/ton LB to $95/ton UB (median = **$55/ton**); based on data for four cities from EPA-530-R-99-013.
  - Total cost (collection + processing) = $35/ton LB to $162/ton UB (median = **$98/ton**).

- National Incremental Cost: Applied to the 12.0 million tons/year incremental recycling to achieve 35%, produces a national incremental cost estimate of ($millions/year):

Estimate range**	$/ton	Capital (22%)	O&M (78%)	Total
Lower-bound:	$35	$92	$328	$420
Most-likely:	$98	$259	$917	**$1,176**
Upper-bound:	$162	$428	$1,516	$1,944

LB = lower-bound = (mean or median – 1 SD); UB = upper-bound = (mean or median + 1SD).

* Based on pooled data points for 30 communities ranging from 1,900 to 6.0 million population, from three reports (EPA-600-R-95-109 July 1995, EPA-530-R-99-013 June 1999, & Waste News magazine17 Feb 2003) for curbside and dropoff recycling programs; normalized by OSW to 2002$ (Mid = median).

** Estimation range (lower-bound and upper-bound) represents +/-1 standard deviation about most-likely value (i.e. 68% confidence interval).

2C.2
MSW Recycling Benefits

National Annual Recycling Benefits Category #1

The national economic cost (i.e. societal cost) for MSW recycling may be formulated as the direct annual cost to municipalities (capital investment costs + annual O&M costs) for operating recycling programs, plus the annual costs to households for participation (waste sorting time + household waste storage + waste drop-off travel costs), minus the following five recycling benefits to society at large which offset the municipal and household direct costs:

- Benefit #1: Market value of pre-processed recyclable materials

	LB	ML	UB
If average value* of recyclable materials is ($/ton):	$6	$10	$25
incremental benefit of 35% goal is (million/year):	$72	$120	$300

* Average values ($/ton) shown above are for recyclable waste "as collected" from the wastestream (e.g. metal "scrap"), rather than for the resale value of recycled materials "as marketed" after recovery processing at a materials recovery facility (e.g. metal "ingots"). Percent of collected recyclable waste retained in the recovery stage for marketing reportedly ranges from 88% (lumber, fiberboard), to 90% (glass, plastics), 91% (office paper), 95% (newspaper, magazines, books), to 100% (aluminum, steel, corrugated cardboard); source: USEPA "Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks", Exhibit 4-3, p.59, EPA-530-R-02-006, May 2002, http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf

LB = lower-bound estimate (-1 std.dev) ML= most likely UB = upper-bound (+1 std.dev)

National Annual Recycling Benefits Category #2

- Benefit #2A: Avoided annual costs for MSW collection & landfilling:
  (Note: this avoided cost estimate does not include possible "negative externalities" to the environment associated with MSW landfills & MSW combustors, thus may understate this benefit)***

	LB	ML	UB
If cost of garbage collection program* is ($/ton):	$43	$69	$167
and garbage disposal cost** is ($/ton):	$30	$36	$58
then total avoided garbage mgmt cost ($/ton):	$73	$105	$225
incremental benefit of 35% goal is (million/year):	$876	$1,260	$2,700

- Benefit #2B: Avoided foregone future land use from expanded landfill sites:
  Incremental 12 million tons/year to achieve 35% would otherwise consume up to:
  (12 mill.tons) x (2.7 to 8.9 CY waste/ton) x (8 to 22 acres landfill per mill.CY waste) =
  260 to 2,350 acres/year (0.4 to 3.7 sq.miles/year)

* Source: EPA-530-R-01-018, Nov 2001 (garbage costs based on sample of 40 US communities; excludes disposal cost).

** Source: Year 2002 landfill tipping fees from http://wasteinfo.com/data.htm (LB=landfills, ML= weighted-avg if 55.3%landfill & 14.5%combustion; UB= combustion (waste-to-energy).

*** The European Commission identified (Oct 2000, 88 pp.) six categories of negative externalities from landfills: (a) gas emissions to air, (b) soil, surface water & groundwater contamination from leachate, (c) future land-use opportunity cost, (d) disamenities (odor, vermin/insects, visual intrusion); (e) fire/explosion hazard, (f) post-closure monitoring & clean-up costs http://europa.eu.int/comm/environment/enveco/waste/cowi_ext_from_landfill.pdf

LB = lower-bound estimate (-1 std.dev) ML= most likely UB = upper-bound (+1 std.dev)

National Annual Recycling Benefit Category #3: Household Willingness-to-Pay for Recycling Civic Duty

- 1999 survey* of households "*willingness-to-pay*" for recycling was 74% more than garbage collection cost (+/-1 std.dev. range of 46% to 120%).

- Household reasons for WTP: 53% good for environment; 13% civic duty; 33% unknown.

	If garbage <u>collect cost is</u>	LB 46%	ML 74%	UP 120% <WTP
Lower-bound:	$43/ton	$20/ton	$32/ton	$52/ton
Most-likely:	$69/ton	$32/ton	$51/ton	$83/ton
Upper-bound:	$167/ton	$77/ton	$124/ton	$200/ton

- Annual household WTP for recycling (note: only 13% of this WTP applied as a benefit in a following slide to avoid possible double-counting with Benefits #4 & #5):

	LB	ML	UB
If range in household average WTP is ($/ton):	$20	$51	$200
then incremental benefit of 35% goal is (mill./yr):	$240	$612	$2,400
And the 13% civic duty component is (mill./yr):	$31	$80	$312

* Source: Thomas Kinnaman, "Explaining the Growth in Municipal Recycling Programs: The Role of Market and Nonmarket Factors", <u>Public Works Management & Policy</u>, Vol.5, No.1, July 2000, pp.37-51.

In absolute measure, two other published studies estimated household "willingness-to-pay" (WTP) for recycling: (a) Williamson County TN 1992 survey for drop-off program surcharge: $11.74/month (suburban recyclers), $7.07/month (rural recyclers), and $4.05/month (rural non-recyclers), Kelly Tiller et al., "Household Willingness to Pay for Dropoff Recycling", <u>Journal of Agricultural & Resource Economics</u>, Vol. 22, No. 2, pp.310-320, 1997; (b) a 1997 survey of Ogden Utah households revealed a mean WTP for curbside recycling of $2.05/month (range $0.52 to $3.59/mo) incremental to their monthly garbage collection bill, with 72% of residents willing to participate (probability range = 66% to 78%), "David Aadland et al., "Household Valuation of Curbside Recycling", <u>Journal of Environmental Planning & Management</u>, Vol. 42, No. 6, pp.781-799, 1999..

National Annual Recycling Benefit Category #4

- Benefit #4: Energy: Net reduction (savings) in upstream & downstream lifecycle manufacturing energy consumption, through substitution of recycled for virgin materials (source: Denison, 1996, p.213, based on 1994 Franklin Assoc Btu multiplier):
  - (12.0 million tons/year) x (18.326 million Btus/ton) = 220,000,000 million Btus/year*
    (0.220 quad* Btus = 37.8 million barrels crude oil equivalency**)
  - @$8.41/million Btu, the additional savings = $1,850 million/year

* Does not include net energy change from the recycling collection/processing compared to garbage collection with landfilling or incineration, to avoid double-counting with unit costs of Benefit #2 compared to recycling unit costs. Recycling collection + MRF processing or recyclables consumes 1.525 million Btus per ton of MSW managed, compared to 0.527 million Btus per ton for MSW garbage collection + landfilling; source: Denison, 1996, p.213).

** 1 quad Btu = 1 quadtrillion Btus = 1 x 10E15 Btus (172.4 million barrels crude oil energy equivalency). US consumed 99.315 quads energy in 2000, consisting of 38.404 quads from crude oil & gas plant liquids (6.62 billion barrels/year or 18.1 million barrels/day), of which 26.046 quads crude oil imported (2.130 billion barrels, or 5.84 million barrels/day).

National Annual Recycling Benefit Category #5

Benefit #5: Health & Environment: Net reduction in environmental pollutant releases compared to manufacturing with virgin materials:

- Avoided atmospheric emissions (GHG carbon, CO, CH, NOx, SOx, PM)
  - Avoid 491 million tons/year pollutant emissions to air*
  - @$1 to $13,500/ton unit benefit (avoided mortality) = $625 million/year
- Avoided waterborne emissions (BOD, COD, phosphate, solids, metals)
  - Avoid 30 million tons/year pollutant emissions to water*
  - @$0.81 to $2.44/ton unit benefit (avoided water treatment cost) = $44,000/year
- Avoided future land disturbance & future natural resource extraction:
  - Avoid harvesting (logging) trees for pulpwood:
    - (12 mill.tons waste/yr) x (45.4% paper**) x (14 trees/ton***) = 76 mill. trees/year equivalent avoided harvested
    - (76 mill. trees/year) x (1 acre pulpwood fores per 400 trees*****) = 190,000 acres/year avoided forests harvested
  - Avoid mining land for metal ores = 187 to 336 million tons/year mining hidden flows avoided
    - Total metals: (12 mill.tons/yr) x (35.4% metals**) = 4.2 mill.tons/year recycled metals
    - Ferrous metals: (4.2 mill.tons/year) x (72%**) x (48.4 tons hidden flows/ton ore****) = 146 mill.tons
    - Aluminum: (4.2 mill.tons/year) x (13%**) x (59.8 tons hidden flows/ton ore****) = 33 mill.tons
    - Other metals: (4.2 mill.tons/year) x (15%**) x (12 to 249 tons h.flows/ton ore****) = 8 to 157 mill.tons

*Source: Based on USEPA Office of Research & Development life-cycle inventory emissions multipliers in 22 Nov 2002 Tellus Institute memo to OSW (Scott Palmer): http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf

** Source: EPA-530-R-02-001, Table 6, p.43, June 2002, http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm

*** Source: Ratio recycled paper type (EPA-530-R-02-001, June 2002, Table 4, p.36) of 80% groundwood paper @24trees/ton & 20%non-GW paper @12 trees/ton from: http://www.conservatree.org/learn/Enviro_Issues/TreeStats.shtml

**** Source: Artti Juutinen, "Industrial Ecology of the Metal Sector", Table 1, 2000, http://www.cc.jyu.fi/helsie/pdf/juutinen.pdf
Hidden flows = all material flows needed in metals mining & processing based on a life-cycle inventory approach.

*****Source: trees/acre recycled paper equivalency from: http://www.rirrc.org/site/educational/rguide_paper.asp

Other National Annual Recycling Benefits

- Sustainable economy: Meet economic and environmental sustainability objectives such as:
  - (a) provide future generations with same resource opportunities as current generation,
  - (b) don't exceed ecological "*carrying capacity*", and
  - (c) reduce "*ecological footprint*" of economy.

- Industrial ecology: Achieve symbiotic, closed-loop, material flow connections between households and industrial processes, whereby discarded household materials ("garbage", "wastes") are recovered by industry as inputs rather than discarded/disposed into the environment (i.e. zero waste).

2C.3 ($millions/year)

Benefit-Cost Analysis of OSW's 35% MSW Recycling Goal

	LB	ML	UB
Incremental total benefits of 35% goal ($million/year):			
#1 Market value of recyclable materials	$72	$120	$300
#2 Avoided garbage mgmt costs	$876	$1,260	$2,700
#3 Household WTP (@13% civic duty) =	$31	$80	$312
#4 Downstream energy reduction* =	$1,295	$1,850	$2,405
#5 Life-cycle pollutant reduction* =	$437	$625	$813
Total annual benefits (if non-duplicative) =	$2,711	$3,935	$6,530
Net benefits of 35% goal ($million/year):			
Annual incremental direct costs =	$420	$1,176	$1,944
Net benefits (benefits minus costs) =	$2,291	$2,759	$4,586
Benefit-Cost Ratio (benefits/costs):**	**6.45**	**3.35**	**3.36**

LB = lower-bound estimate (-1 std.dev) ML= most likely UB = upper-bound (+1 std.dev)

* LB and UB estimates assigned to benefit categories #4 and #5 based on -/+30% of ML value, respectively.

** In comparison to this national benefit-cost ratio estimate, one published study estimated a rural county-wide benefit-cost ratio of 8.8, based on a county dropoff recycling program cost (1992) of $0.46/month per household, relative to a survey household willingness-to-pay of $4.05/month for rural non-recyclers; Kelly Tiller et al., "Household Willingness to Pay for Dropoff Recycling", Journal of Agricultural & Resource Economics, Vol.22, No.2, pp.310-320, 1997.

2C.3 ($/ton average)

Benefit-Cost Analysis of OSW's 35% MSW Recycling Goal

	LB	ML	UB
■ Incremental total benefits of 35% goal ($/ton):			
❑ #1 Market value of recyclable materials	$6	$10	$25
❑ #2 Avoided garbage mgmt costs	$73	$105	$225
❑ #3 Household WTP (@13% civic duty) =	$3	$7	$26
❑ #4 Downstream energy reduction* =	$108	$154	$200
❑ #5 Life-cycle pollutant reduction* =	$36	$52	$68
Total annual benefits (if non-duplicative) =	$226	$328	$544
■ Net benefits of 35% goal ($/ton):			
❑ Annual incremental direct costs =	$35	$98	$162
❑ Net benefits (benefits minus costs) =	$191	$230	$382
■ Benefit-Cost Ratio (benefits/costs)**:	**6.45**	**3.35**	**3.36**

LB = lower-bound estimate (-1 std.dev) ML= most likely UB = upper-bound (+1 std.dev)

* LB and UB estimates assigned to benefit categories #4 and #5 based on -/+30% of ML value, respectively.

** In comparison to this national benefit-cost ratio estimate, one published study estimated a rural county-wide benefit-cost ratio of 8.8, based on a county dropoff recycling program cost (1992) of $0.46/month per household, relative to a survey household willingness-to-pay of $4.05/month for rural non-recyclers; Kelly Tiller et al., "Household Willingness to Pay for Dropoff Recycling", Journal of Agricultural & Resource Economics, Vol.22, No.2, pp.310-320, 1997.

2C.4

Potential Impact of 35% Recycling Goal on US Employment

A. Employment Baseline Reference Data (source: 1997 Economic Census):

MSW Mgt	NAICS	1997 estabs	1997 workers	1997 revenue (billions)	1997 payroll (millions)	1997 tons MSW managed	1997 tons/yr per worker	1997 avg revenue per ton	1997 avg worker payroll
Recycling	562920	765	10,846	$1.299	$283.5	59.03	5,443	$22.01	$26,136
Landfill	562212	1,403	27,454	$5.493	$887.1	125.54	4,573	$43.76	$32,311
Combust.	562213	105	2,976	$1.129	$132.6	34.79	11,689	$32.44	$44,554
Column totals =		2,273	41,276	$7.921	$1,303.1	219.36	5,314	$36.11	$31,572

Note: Solid waste collection services (NAICS 562111) employment not analyzed; assumes MSW collection quantity is unchanged.

B. Potential Impact on Employment (2001 update year; parentheses indicate decrease):

MSW Mgt	35% increment (mill. tons/yr)	Change in employment (workers)	Change in revenues ($millions)	Change in payroll ($millions)
Recycling	12.0	2,208	$288	$76
Landfill	(9.5)	(2,079)	($453)	($89)
Combust.	(2.5)	(215)	($89)	($13)
Column totals = 0		**(86)**	($253)	($25)

Note: One published study postulates the following macroeconomic implications of recycling: "[E]xpansion of recycling will reduce dependence on imports and thus improve the balance-of-payments. Furthermore, and autonomous reduction in imports is then assumed to create a multiplier effect, as there is a net injection to the circular flow of income, causing GNP to rise. Finally, the higher GNP is assumed to create an expansion in the requirement of labor, thus reducing unemployment." This study examined two countries and estimated 0.29% and 2.3% annual increases in GNP from 5% and 40% recycling rates, respectively (for Italy), and 0.88% and 1.76% annual increases in GNP from 5% and 10% recycling rate increases, respectively (for United Kingdom); V. Rich et al., "Macroeconomic Implications of Recycling: A Response to Di Vita", Resources Policy, Vol.25, pp.141-142, 1999.

2D. Potential* for Recycling Beyond 35%:

2D.1 Maximum economically-beneficial recycling "net cost"
2D.2 Potential impact of meeting unmet state goals (2010)
2D.3 Potential impact of expanded recycling population coverage
2D.4 Sample of opinions on maximum recycling rates achievable
2D.5 Enhancing national recycling rates
2D.6 Role of recycling in environmental protection

* Note: The following slides present a "supply-side" portrayal of MSW recycling potential; achievement of future potential depends upon "demand-side" complementarity (i.e. capacity of industries to purchase and utilize increasing annual quantities of recyclable materials).

2D.1 Estimate of Recycling "Net Cost" (Pooled Data from 30 Cities)

Pooled Data (3 data sets): MSW Recycling "Net Cost" (Collection Cost + MRF Processing Cost - Material Revenues)

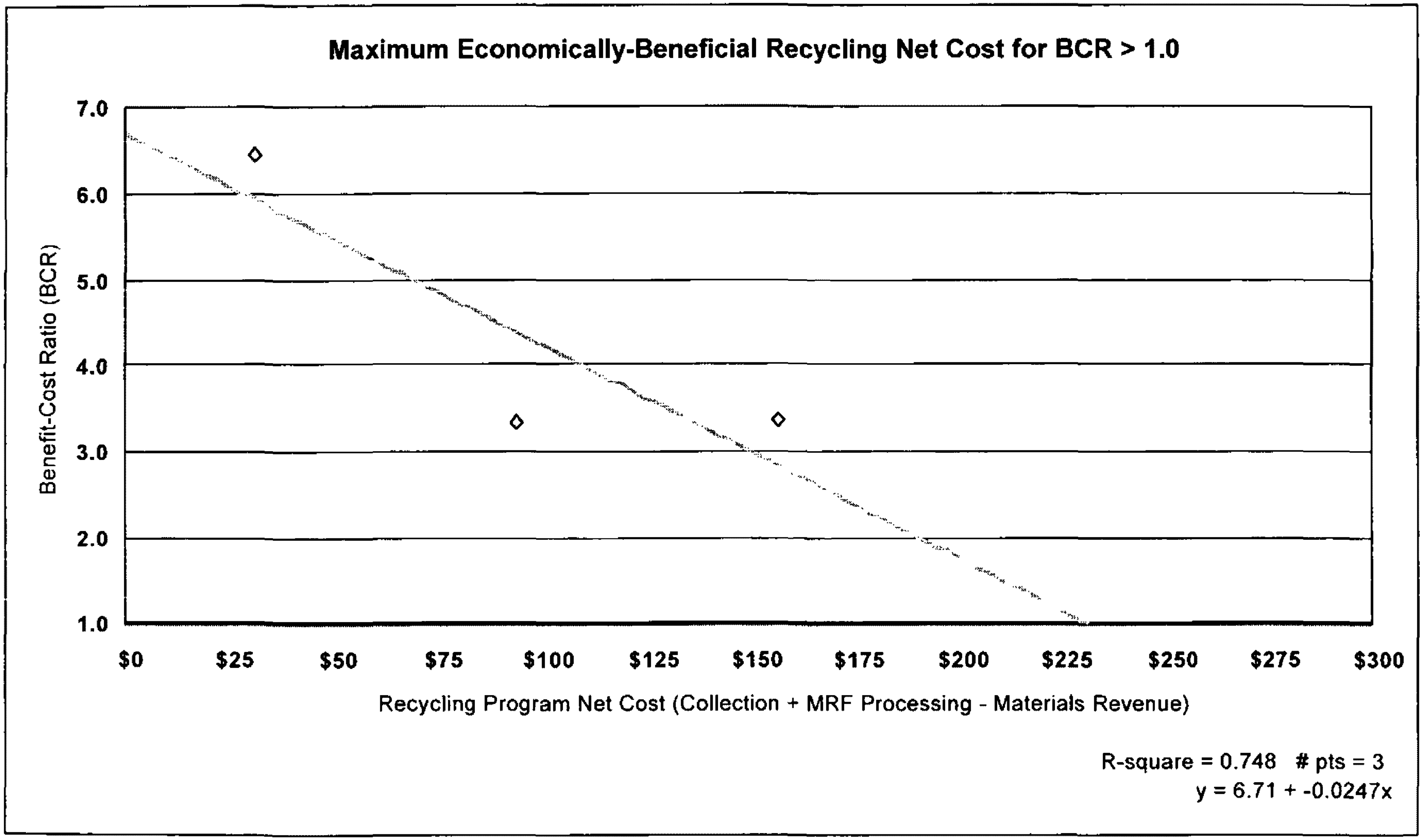
A. Reference Data:

A Data item	B Recycling program cost ($/ton)	C Recycling processing ($/ton)	D Materials revenues ($/ton)	E (D/B) Revenue offset percentage	F (B+C-D) Recycling net cost ($/ton)	G Data year	H Data source	I Type
1	$73.00	$14.00	$9.07	12.4%	$77.93	1996$	EPA-530-R-99-013	Curb+dropoff
2	$38.72	included	$7.98	20.6%	$30.74	1996$	EPA-530-R-99-013	Curb+dropoff
3	$46.00	$55.00	$4.81	10.5%	$96.19	1996$	EPA-530-R-99-013	Curb+dropoff
4	$88.91	$100.00	$17.01	19.1%	$171.90	1996$	EPA-530-R-99-013	Curb+dropoff
5	$51.29	unknown	$16.99	33.1%	$34.30	1996$	EPA-530-R-99-013	Curb+dropoff
6	$128.00	unknown	$10.61	8.3%	$117.39	1996$	EPA-530-R-99-013	Curb+dropoff
7	$118.00	$42.00	$12.65	10.7%	$147.35	1996$	EPA-530-R-99-013	Curb+dropoff
8	$196.00	included	$14.64	7.5%	$181.36	1996$	EPA-530-R-99-013	Curb+dropoff
9	$36.00	excluded	$36.00	100.0%	$0.00	1993$	EPA-600-R-95-109	Dropoff
10	$17.16	excluded	$17.16	100.0%	$0.00	1993$	EPA-600-R-95-109	Dropoff
11	$23.99	excluded	$23.99	100.0%	$0.00	1993$	EPA-600-R-95-109	Dropoff
12	$4.94	excluded	$4.94	100.0%	$0.00	1993$	EPA-600-R-95-109	Dropoff
13	$4.22	excluded	$4.22	100.0%	$0.00	1993$	EPA-600-R-95-109	Dropoff
14	$7.71	excluded	$7.71	100.0%	$0.00	1993$	EPA-600-R-95-109	Dropoff
15	$4.13	excluded	$4.13	100.0%	$0.00	1993$	EPA-600-R-95-109	Dropoff
16	$3	excluded	$0.01	0.5%	$2.69	2002$	Waste News Feb 2003	Curb+dropoff
17	$187	excluded	$18.91	10.1%	$168.33	2002$	Waste News Feb 2003	Curb+dropoff
18	$64	excluded	$2.49	3.9%	$61.36	2002$	Waste News Feb 2003	Curb+dropoff
19	$210	excluded	$2.46	1.2%	$207.65	2002$	Waste News Feb 2003	Curb+dropoff
20	$17	excluded	$1.00	5.8%	$16.35	2002$	Waste News Feb 2003	Curb+dropoff
21	$98	excluded	$26.84	27.3%	$71.58	2002$	Waste News Feb 2003	Curb+dropoff
22	$12	excluded	$3.53	28.2%	$8.96	2002$	Waste News Feb 2003	Curb+dropoff
23	$41	excluded	$37.66	91.6%	$3.44	2002$	Waste News Feb 2003	Curb+dropoff
24	$135	excluded	$0.58	0.4%	$134.05	2002$	Waste News Feb 2003	Curb+dropoff
25	$92	excluded	$4.33	4.7%	$87.53	2002$	Waste News Feb 2003	Curb+dropoff
26	$34	excluded	$0.04	0.1%	$34.43	2002$	Waste News Feb 2003	Curb+dropoff
27	$84	excluded	$13.04	15.5%	$70.88	2002$	Waste News Feb 2003	Curb+dropoff
28	$124	excluded	$17.11	13.8%	$107.33	2002$	Waste News Feb 2003	Curb+dropoff
29	$120	excluded	$44.45	36.9%	$76.01	2002$	Waste News Feb 2003	Curb+dropoff
30	$167	excluded	$32.10	19.2%	$134.95	2002$	Waste News Feb 2003	Curb+dropoff
Min =	$2.71		$0.01	0.1%	$0.00			
Max =	$210.11		$44.45	100.0%	$207.65			
Median =	$57.57		$9.84	17%	$66.12			
Mean =	$74.27		$13.22	36.0%	$68.09			

B. Normalized to 2002$:

J Data item	K Recycling program cost ($/ton)	L Recycling processing ($/ton)	M Materials revenues ($/ton)	N (K+L-M) Recycling net cost ($/ton)	O (K+L) Recycling total cost ($/ton)
1	$82.57	$15.84	$10.26	$88	$98.41
2			$9.03		
3	$52.03	$62.21	$5.44	$109	$114.24
4	$100.57	$113.11	$19.24	$194	$213.68
5	$58.02		$19.22	$39	$58.02
6	$144.78		$12.00	$133	$144.78
7	$133.47	$47.51	$14.31	$167	$180.98
8			$16.56		
9	$43.53	$33	$43.53	$33	$76.34
10	$20.75	$33	$20.75	$33	$53.55
11	$29.01	$33	$29.01	$33	$61.81
12	$5.97	$33	$5.97	$33	$38.78
13	$5.10	$33	$5.10	$33	$37.91
14	$9.32	$33	$9.32	$33	$42.13
15	$4.99	$33	$4.99	$33	$37.80
16	$187	$33	$18.91	$201	$220.04
17	$64	$33	$2.49	$94	$96.65
18	$210	$33	$2.46	$240	$242.91
19	$17	$33	$1.00	$49	$50.16
20	$98	$33	$26.84	$104	$131.22
21	$12	$33	$3.53	$42	$45.29
22	$41	$33	$37.66	$36	$73.90
23	$135	$33	$0.58	$167	$167.43
24	$92	$33	$4.33	$120	$124.67
25	$34	$33	$0.04	$67	$67.28
26	$84	$33	$13.04	$104	$116.72
27	$124	$33	$17.11	$140	$157.24
28	$120	$33	$44.45	$109	$153.27
29	$167	$33	$32.10	$168	$199.85
Min =	$5	$16	$0.04	$33	$38
Max =	$210	$113	$44	$240	$243
Median =	$64	$55	$12	$94	$98
Mean =	$77	$60	$15	$96	$111
Std.dev =	$60	$41	$13	$63	$63
Median -1SD =	$4	$14	$6	$32	$35
Median + 1SD =	$124	$95	$25	$157	$162

Maximum Economically-Beneficial Recycling "Net Cost" = $225/ton
(projection of X-Y plot based on LB, ML, UB pooled data in cost & benefits pages)



2D.2

National MSW Recycling Rate Potential for Year 2010, Implied by 33.2 Million Tons/Year Unmet & Future State Recycling Goals

Franklin Associates data:

- 69.9 million tons/year MSW recycled (2000)
- 69.9 + 33.2 = 103.1 MTY MSW recycling potential year 2010
- (103.1 MTY recycled)/(231.9 MTY MSW generated in 2000) = **45%**

BioCycle magazine data:

- 130.5 million tons/year MSW recycled (2000)
- 130.5 + 33.2 = 163.7 MTY MSW recycling potential year 2010
- (163.7 MTY recycled)/(409.0 MTY MSW generated in 2000) = **40%**

Urban & Rural MSW Recycling Penetration (2000)

Estimate of Large Urban, Small Urban & Rural Populations Served by MSW Recycling (2000)

		A. State Total MSW Recycling Penetration:						B. Large Urban Recycling Penetration:			C. Small Urban Recycling Penetration:				D. Rural Penetration:		
		A	B	C	D (10%xC/90%)	E (C+D)	F (E/D)	G	H (E/G)	I (GxH if<100%)	J	K (G+J)	L (E/K)	M (KxL-V)	N (B-K)	O (N-B)	P (E-K)/N
Item	State	2000 housing units	2000 population	BioCycle curbside population served 2000	OSW estimate of dropoff population 10.0%	OSW estimate total recycling population served	% of popltn served by recycling	Urbanized area (UA) population	% of UA served by recycling	UA popltn served by recycling	Urbanized cluster (UC) population	UA + UC population	% of UA+UC served by recycling	UC popltn served by recycling	Rural population	% rural	% of rural served by recycling
1	Alabama	1,963,711	4,447,100	1,100,000	122,222	1,222,222	27.5%	1,941,208	63.0%	1,222,222	524,465	2,465,673	49.6%	0	1,981,427	44.6%	0.0%
2	Alaska	260,978	626,932	0	0	0	0.0%	277,670	0.0%	0	133,587	411,257	0.0%	0	215,675	34.4%	0.0%
3	Arizona	2,189,189	5,130,632	2,430,000	270,000	2,700,000	52.6%	3,908,163	69.1%	2,700,000	615,372	4,523,535	59.7%	0	607,097	11.8%	0.0%
4	Arkansas	1,173,043	2,673,400					860,747			543,432	1,404,179			1,269,221	47.5%	
5	California	12,214,549	33,871,648	31,146,000	0	31,146,000	92.0%	29,950,008	104.0%	29,950,008	2,039,655	31,989,663	97.4%	1,195,992	1,881,985	5.6%	0.0%
6	Colorado	1,808,037	4,301,261					3,212,849			9,238	3,222,087			1,079,174	25.1%	
7	Connecticu	1,385,975	3,405,565	3,405,565	0	3,405,565	100.0%	2,848,497	119.6%	2,848,497	139,562	2,988,059	114.0%	139,562	417,506	12.3%	100.0%
8	DC	274,845	572,059					531,032			0	531,032			41,027	7.2%	
9	Delaware	343,072	783,600	4,000	444	4,444	0.6%	572,059	0.8%	4,444	96,726	668,785	0.7%	0	114,815	14.7%	0.0%
10	Florida	7,302,947	15,982,378	8,500,000	944,444	9,444,444	59.1%	13,470,104	70.1%	9,444,444	799,916	14,270,020	66.2%	0	1,712,358	10.7%	0.0%
11	Georgia	3,281,737	8,186,453					5,010,117			854,046	5,864,163			2,322,290	28.4%	
12	Hawaii	460,542	1,211,537	400,000	44,444	444,444	36.7%	835,912	53.2%	444,444	272,313	1,108,225	40.1%	0	103,312	8.5%	0.0%
13	Idaho	527,824	1,293,953					603,808			255,689	859,497			434,456	33.6%	
14	Illinois	4,885,615	12,419,293	8,051,000	894,556	8,945,556	72.0%	9,737,473	91.9%	8,945,556	1,172,047	10,909,520	82.0%	0	1,509,773	12.2%	0.0%
15	Indiana	2,532,319	6,080,485	4,170,000	463,333	4,633,333	76.2%	3,410,932	135.8%	3,410,932	893,079	4,304,011	107.7%	893,079	1,776,474	29.2%	18.5%
16	Iowa	1,232,511	2,926,324	1,983,000	220,333	2,203,333	75.3%	1,114,790	197.6%	1,114,790	671,979	1,786,769	123.3%	671,979	1,139,555	38.9%	36.6%
17	Kansas	1,131,200	2,688,418	1,223,000	135,889	1,358,889	50.5%	1,207,832	112.5%	1,207,832	712,837	1,920,669	70.8%	151,057	767,749	28.6%	0.0%
18	Kentucky	1,750,927	4,041,769	590,000	65,556	655,556	16.2%	1,566,760	41.8%	655,556	687,040	2,253,800	29.1%	0	1,787,969	44.2%	0.0%
19	Louisiana	1,847,181	4,468,976					2,535,614			710,051	3,245,665			1,223,311	27.4%	
20	Maine	651,901	1,274,923	487,000	54,111	541,111	42.4%	313,952	172.4%	313,952	198,926	512,878	105.5%	198,926	762,045	59.8%	3.7%
21	Maryland	2,145,283	5,296,486	3,600,000	400,000	4,000,000	75.5%	4,247,989	94.2%	4,000,000	310,679	4,558,668	87.7%	0	737,818	13.9%	0.0%
22	Massachus	2,621,989	6,349,097	4,832,000	536,889	5,368,889	84.6%	5,635,129	95.3%	5,368,889	166,238	5,801,367	92.5%	0	547,730	8.6%	0.0%
23	Michigan	4,234,279	9,938,444	2,951,000	327,889	3,278,889	33.0%	6,578,451	49.8%	3,278,889	841,006	7,419,457	44.2%	0	2,518,987	25.3%	0.0%
24	Minnesota	2,065,946	4,919,479	3,700,000	411,111	4,111,111	83.6%	2,711,750	151.6%	2,711,750	778,309	3,490,059	117.8%	778,309	1,429,420	29.1%	43.4%
25	Mississippi	1,161,953	2,844,658	325,000	36,111	361,111	12.7%	679,928	53.1%	361,111	707,423	1,387,351	26.0%	0	1,457,307	51.2%	0.0%
26	Missouri	2,442,017	5,595,211					3,090,644			792,798	3,883,442			1,711,769	30.6%	
27	Montana	412,633	902,195					234,195			253,683	487,878			414,317	45.9%	
28	Nebraska	722,668	1,711,263	500,000	55,556	555,556	32.5%	805,111	69.0%	555,556	388,614	1,193,725	46.5%	0	517,538	30.2%	0.0%
29	Nevada	827,457	1,998,257	1,622,000	180,222	1,802,222	90.2%	1,676,309	107.5%	1,676,309	152,337	1,828,646	98.6%	125,913	169,611	8.5%	0.0%
30	New Hampi	547,024	1,235,786	511,000	56,778	567,778	45.9%	551,828	102.9%	551,828	180,486	732,314	77.5%	15,950	503,472	40.7%	0.0%
31	New Jersey	3,310,275	8,414,350	7,500,000	833,333	8,333,333	99.0%	7,753,792	107.5%	7,753,792	185,295	7,939,087	105.0%	185,295	475,263	5.6%	83.0%
32	New Mexic	780,579	1,819,046	400,000	44,444	444,444	24.4%	862,344	51.5%	444,444	501,157	1,363,501	32.6%	0	455,545	25.0%	0.0%
33	New York	7,679,307	18,976,457	17,230,000	0	17,230,000	90.8%	15,504,619	111.1%	15,504,619	1,097,963	16,602,582	103.8%	1,097,963	2,373,875	12.5%	26.4%
34	North Carol	3,523,944	8,049,313	3,500,000	388,889	3,888,889	48.3%	3,760,871	103.4%	3,760,871	1,088,611	4,849,482	80 2%	128,018	3,199,831	39.8%	0.0%
35	North Dako	280,677	642,200	100,000	11,111	111,111	17.3%	230,797	48.1%	111,111	128,161	358,958	31.0%	0	283,242	44.1%	0.0%
36	Ohio	4,783,051	11,353,140					7,311,293			1,471,036	8,782,329			2,570,811	22.6%	
37	Oklahoma	1,514,400	3,450,654	1,057,000	117,444	1,174,444	34.0%	1,483,638	79.2%	1,174,444	770,925	2,254,563	52.1%	0	1,196,091	34.7%	0.0%
38	Oregon	1,452,709	3,421,399	2,633,000	292,556	2,925,556	85.5%	1,976,124	148.0%	1,976,124	718,020	2,694,144	108.6%	718,020	727,255	21.3%	31.8%
39	Pennsylvan	5,249,750	12,281,054	8,800,000	977,778	9,777,778	79.6%	8,210,985	119.1%	8,210,985	1,253,116	9,464,101	103.3%	1,253,116	2,816,953	22.9%	11.1%
40	Rhode Islar	439,837	1,048,319	890,000	98,889	988,889	94.3%	928,119	106.5%	928,119	25,027	953,146	103.7%	25,027	95,173	9.1%	37.6%
41	South Caro	1,753,670	4,012,012	1,676,000	186,222	1,862,222	46.4%	1,873,821	99.4%	1,862,222	553,303	2,427,124	76.7%	0	1,584,888	39.5%	0.0%
42	South Dak	323,208	754,844					194,584			196,843	391,427			363,417	48.1%	
43	Tennessee	2,439,443	5,689,283					2,964,722			655,296	3,620,018			2,069,265	36.4%	
44	Texas	8,157,575	20,851,820	5,000,000	555,556	5,555,556	26.6%	14,795,862	37.5%	5,555,556	2,408,419	17,204,281	32.3%	0	3,647,539	17.5%	0.0%
45	Utah	768,594	2,233,169					1,748,080			222,264	1,970,344			262,825	11.8%	
46	Vermont	294,382	608,827	325,000	36,111	361,111	59.3%	105,365	342.7%	105,365	127,083	232,448	155.4%	127,083	376,379	61.8%	34.2%
47	Virginia	2,904,192	7,078,515	1,144,000	127,111	1,271,111	18.0%	4,713,302	27.0%	1,271,111	456,653	5,169,955	24.6%	0	1,908,560	27.0%	0.0%
48	Washingtoı	2,451,075	5,894,121	4,787,000	531,889	5,318,889	90.2%	4,303,803	123.6%	4,303,803	527,303	4,831,106	110.1%	527,303	1,063,015	18.0%	45.9%
49	West Virgir	844,623	1,808,344					512,427			320,353	832,780			975,564	53.9%	
50	Wisconsin	2,321,144	5,363,675	3,173,000	352,556	3,525,556	65.7%	2,842,494	124.0%	2,842,494	821,149	3,663,643	96.2%	683,062	1,700,032	31.7%	0.0%
51	Wyoming	223,854	493,782	20,000	2,222	22,222	4.5%	125,921	17.6%	22,222	195,423	321,344	6.9%	0	172,438	34.9%	0.0%
	United States	115,904,641	281,421,906	139,765,565	9,776,000	149,541,565	53.1%	**192,323,824**	**71.0%**	136,594,292	**29,624,933**	221,948,757		8,915,653	59,473,149	21.1%	1.4%
				49.7%	3.5%	53.1%		68.3%			10.5%	78.9%	5,419,716	30.1%	21.1%		853,775

Bureau of Census definitions: UA = contiguous census block groups usually >1,000 ppsm & together >50,000 total population; UC = block groups usually <1,000 ppsm & together 2,500 to 50,000 total population.

2D.3

Future National Recycling Rate if Expand Population Coverage

A. Proportion of US Population Served by MSW Recycling Programs (2000):

Population category	2000 US population (millions)	Population served by recycling*		Unserved gap	
Large urban	192.3	136.6	71%	55.7	29%
Small urban	29.6	8.9	30%	20.7	70%
Rural	59.5	0.9	1.4%	58.6	98.6%
Total US =	281.4	146.4	52%	135.0	48%

B. Potential Future National MSW Recycling Rate if Expand Population Coverage:

Urban category	Expanded population served (millions)	Potential Rate 2000 Baselines Franklin	BioCycle
If 100% large urban	146.4+55.7 = 202.1 (72%)	**42%**	**44%**
If 100% large + small	146.4+55.7+20.7 = 222.8 (79%)	**46%**	**49%**
If 100% urban + rural**	281.4 (100%)	**58%****	**61%****

* Based on BioCycle magazine, Dec. 2001, Table 6, p.47.

** In many states, expansion of recycling programs to 100% rural coverage may not be economically-beneficial because of higher truck collection costs for longer travel distances in low-density population areas; although one state (CT with 12.3% rural pop.) reports 100% of population served in 2000.[81]

2D.4

Sample of Opinions on Maximum Recycling Rates

- 1990 opinion: Institute for Local Self-Reliance: From "*Beyond 40 Percent: Record-Setting Recycling & Composting Programs*" (1990): "When our first volume 'Beyond 25 Percent' was published in May 1989, only 33% of the 15 best recycling and composting programs were recovering more than 40% of their waste streams. Of the 17 programs in this study concluded only one year later, 60% are recovering **40%** or more… All the programs documented in this report -- even the best – can increase their materials recovery levels."

- 1997 opinion: Finnish Forest Research Institute: "A Post-Consumer Waste Management Model for Determining Optimal Levels of Recycling & Landfilling" (1997): "The present study examines the optimal recycling rate for MSW. The benefits from recycling are included in the simulation using the results of a recent contingent valuation study. The results of the present research suggest that mandates achieving **50%** recycling in municipalities are not far-fetched and are both economically and environmentally justified."

- 1999 opinion: City of Los Angeles Solid Resources Collection Division: "Los Angeles recently conducted a study that indicated recyclable materials comprised 40% of the total [Los Angeles] waste stream… We know it's not possible to recycle the entire 40%, but we're confident we can reach a **30%** residential recycling rate."

- 1999 opinion: New York City Bureau of Waste Prevention, Reuse & Recycling: "People are beginning to see that 25% may be a limit for cities… It's a different situation in, say, Seattle, where there is an enormous amount of yard waste; when you look at what's available in a residential sector's trash and what has a market, you're looking at an upper limit close to **25%.**"

- 2003 opinion: Franklin Assoc.: From "*Recycling – Is 50% A Reasonable Goal?*" (2003): "[W]e believe it will not be possible to reach a 50% recovery rate by 2010 without draconian measures… If some products generated in large quantities (i.e. yard trimmings, food wastes, mixed papers) could be pushed to higher recovery levels, **40%** might be achieved with a good deal of effort."

2D.5
Enhancing Recycling's Economic Potential

"Recycling is more expensive for communities than it needs to be, partly because traditional recycling tries to force materials into more lifetimes than they were designed for – a complicated and messy conversion, and one that itself expends energy and resources. Very few objects of modern consumption were designed with recycling in mind. **If the [recycling] process is truly to save money and materials, products must be designed from the very beginning to be recycled** or even "upcycled" – a term we use to describe the return to industrial systems of materials with improved, rather than degraded, quality."

Source: William McDonough & Michael Braungart, "The Next Industrial Revolution", The Atlantic Monthly, Vol. 282, No. 4, Oct 1998, pp.82-92; http://www.theatlantic.com/issues/98oct/industry.htm

Enhancing Recycling's Economic Potential (cont'd)

"Economic welfare analysis tells us that the amount of recycling undertaken by consumers will be less than optimal for two reasons:

- First, recycling creates a **positive externality** in that everyone benefits from my recycling efforts (saving landfill space and reducing landfill costs). In the absense of a one-to-one correspondence between those who make the effort and those who reap the benefit, many will not make the effort voluntarily.
- Second, recycling is an **intergenerational public good**. Our recycling efforts today will help to eliminate a potential problem in the future. Given the myopic time preference of most individuals, people will undervalue the current benefits of recycling.

The above two factors cause the **private marginal benefit** from recycling to be less than the **social marginal benefit**. From society's perspective, not enough recycling will be done by individuals because they cannot capture, or are not compensated for, all of the benefits of their efforts. Therefore, **any large scale recycling program must be government initiated, either through mandatory regulations or economic incentives**. Considering the magnitude of the problem, it is only a matter of time before legislation is introduced to implement recycling on a national level."

Source: Vijaya Duggal et al., School of Management, Widener Univ., "Recycling: An Economic Analysis", Eastern Economic Journal, Vol. XVII, No. 3, July-Sept 1991, p.352.)

Economic Incentives for Enhancing Recycling: Empirical Results from 1997 Study* of All 351 Towns in Mass.

- Unit pricing: A community implementing a quantity-based unit pricing system, rather than a flat monthly fee, for MSW garbage collection can expect its annual recycling rate to be **6.6 % points** higher than if it had used an alternative garbage collection pricing approach. Because flat fees are not quantity-dependent, they give households no incentive to economize on waste generation or disposal, a classic market failure.
- Curbside service: An additional increase of **5.5 % points** in the annual recycling rate (totaling **12.1 % points**) is predicted if the MSW garbage unit pricing system is accompanied by the provision of curbside recycling services, which by itself should increase the annual recycling rate by **4.2 % points**.
- Disposal cost: Similarly, if policy initiatives elevate the cost of garbage disposal, the *relative cost* of recycling falls, and aggregate annual recycling rates should rise. Conversely, the public provision of free MSW garbage collection decreases the opportunity cost of disposal relative to recycling, thereby lowering the annual recycling rate (MSW landfill tipping fees in 2003 average only $30/ton).
- MRF: A community using a state-funded materials recovery facility (MRF) can expect to achieve an average increase of **9.5 % points** in its annual recycling rate, because free access to a state-funded MRF may allow relatively small communities to experience savings in recycling costs typically associated only with more densely-populated communities, translating into higher recycling levels.
- Education: Each additional grant dollar awarded per household for recycling education should increase a community's annual recycling rate by **2.6 % points**.
- Equipment: Grants for recycling equipment should encourage public provision of recycling services by lowering the cost of doing so, which should in turn lower resident's opportunity cost of recycling, leading to a higher recycling rate.

* Source: Scott Callan & Janet Thomas, "The Impact of State & Local Policies on The Recycling Effort", Eastern Economic Journal, Vol. 23, No. 4, Fall 1997, pp.411-423.

2D.6

Role of Recycling in Environmental Protection

"Even as we applaud the desirability of the recycling movement, it is nonetheless true that it has become a symbolic act of political correctness that in some cases convinces individuals, firms, interest groups, and government entities that they are doing *all they need to do* for the environment. In this sense, [recycling] can serve as somewhat of an "inoculation" against catching the fully virulent contagious form of environmentalism… Putting all faith and energies into recycling, since that de facto allows a full-scale embrace of the consumer society, might allow us to be lulled dangerously to sleep at a time when the appropriate action might be to adjust or cancel an action at the outset. The mindset which urges us to "go ahead and do it, and we'll simply recycle all materials" will be patently inadequate, even with the most comprehensive of recycling plans… In summary, **recycling is vitally important, but viewed in this manner it reminds us that it is merely a necessary but partial solution to the jigsaw puzzle of sustainability**."

Source: "Recycling in Theory and Practice", Chapter 5 in Reuniting Economy & Ecology in Sustainable Development, Russ Beaton & Chris Maser, Lewis Publishers, 1999, pp.73-84; http://www.chrismaser.com/bk-reesd.htm

Appendices

- Appendices A&B: Exploratory X-Y Statistical Plot Graphs to Compare State & City MSW Recycling Infrastructure Indicators & Unit Costs
  - Appendix A: State Recycling Infrastructure (1 data set)
  - Appendix B: Municipal Recycling Infrastructure (2 data sets)

- Appendix C: Four Alternative Study Plan Options for this Assessment

Appendices A & B: Exploratory X-Y Statistical Plots

- <u>Recycling infrastructure indicators</u>: The following graphs display X-Y data plots of recycling rates and recycling costs ($/ton), compared to recycling infrastructure indicators (e.g. coverage, participation) for states and municipalities:
  - Measures of population & population density served by recycling programs/facilities
  - Measures of land area & count of municipalities served
  - Recycling budgets
  - Measures of households served

- <u>Indicator associations</u>: Best-fit data curves are displayed for each X-Y plot to test "goodness-of-fit" between recycling rates/costs and infrastructure indicators, based on four alternative mathematical formulations (linear, logarithmic, exponential, power). Data curves are tests for degree of statistical associations, not for causality.

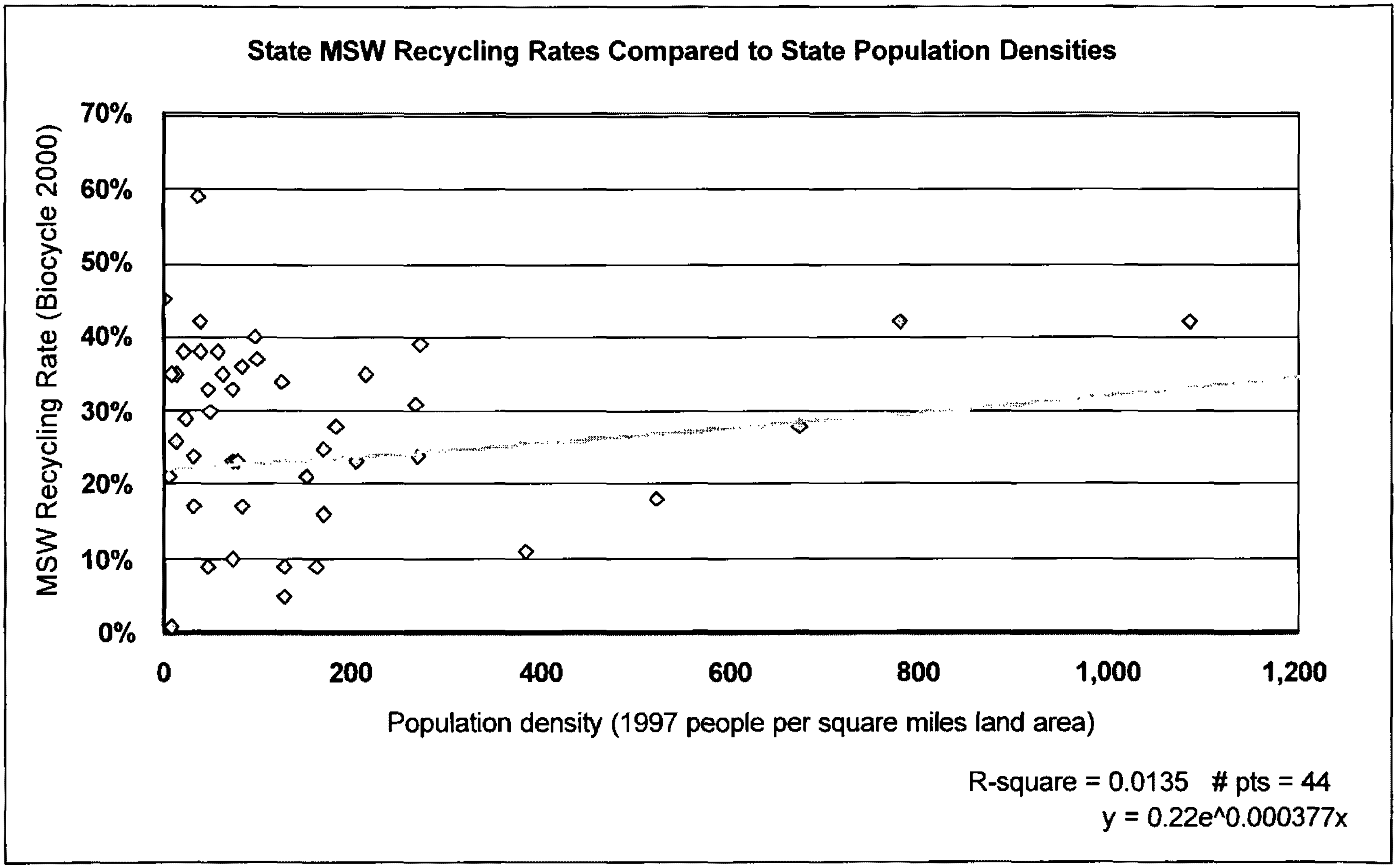
Appendix A:
State Recycling Rates & Infrastructure (exploratory X-Y plot graphs based on one data set)

State MSW Recycling Database for Exploratory X-Y Plots

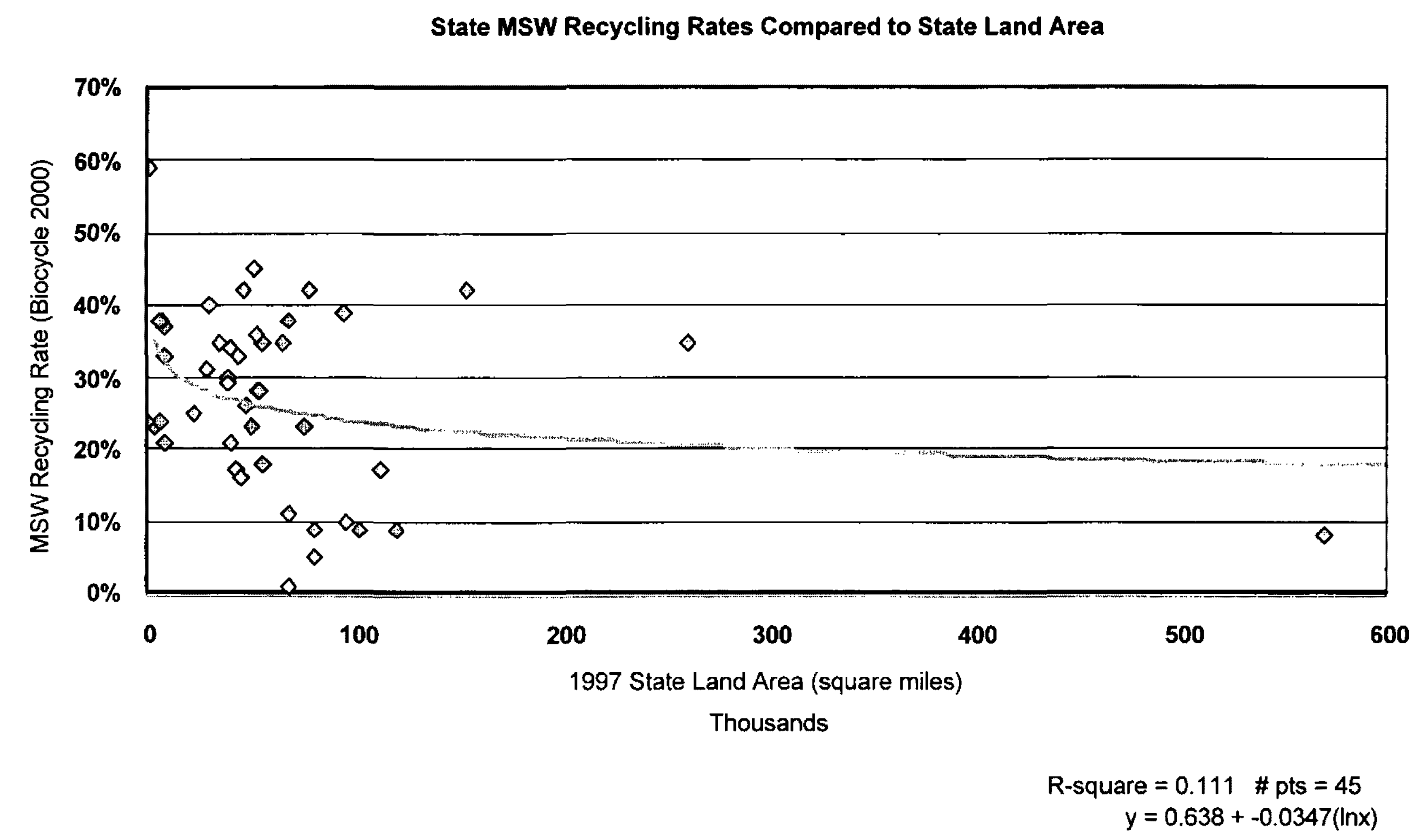
State-By-State MSW Recycling Data Compared to State-wide Demographics

		A. MRF Statistics from 1997 Economic Census (NAICS 562920):									B. State-Wide MSW Recycling Data:									C. State-Wide Recycling Penetration:						
		A	B	C	D	E	F	G	H	I (E/F)	J	K	L	M	N	O	P	Q	R	S (E/A)	T (F/A)	U (E/R)	V (F/R)	W (G/R)	X (H/R)	Y (N/E)
Item	State	MRF estabs 1997	MRF employees 1997	MRF payroll ($1000)	MRF revenues ($1000)	1997 State population	State land area (sq.miles)	Incorprtd places 1990	2000 count households	State popln density 1997	EPA-OSW MSW recycling rate 1996	BioCycle MSW recycling rate 2000	BioCycle MSW tons recycled 2000	% popln served by curbside recycling 2000	State annual recycling budget 2000	Per capita 1998 state budget capital for environment	1996-98 households in income poverty (% of popln)	Worker mean annual pay 2000	BioCycle curbside recycling programs 1999	State popln per MRF 1997	State sq.miles land area per MRF 1997	State population per curb-side progr	State sq.miles land area per curbside program	State places per curbside program	State households per curbside program	State annual recycling budget per capita
0	US total	765	10,846	283,476	1,299,033	267,743,595	3,536,342	19,289	105,480,101	76		32%	409,029,000		$172,999,000					349,992	4,623					$0.646
1	Alabama	8	50	750	4,480	4,322,113	50,750	439	1,737,080	85	20%	23%	4,500,000	25%	$250,000	$41.45	14.7%	$29,041	38	540,264	6,344	113,740	1,336	12	45,713	$0.058
2	Alaska	1	0 to 19	Withheld	Withheld	609,655	570,374	152	221,600	1	7%	8%	686,000	0%	$0	$431.08	8.8%	$35,144	1	609,655		609,655				$0
3	Arizona	12	171	4,208	16,667	4,553,249	113,642	86	1,901,327	40	14%	17%	5,750,000	47%	$2,260,000	$33.37	18.1%	$32,610	32	379,437	9,470	142,289	3,551	3	59,416	$0.496
4	Arkansas	5	37	692	2,929	2,523,186	52,075	487	1,042,696	48	36%	45%	2,056,000		$0	$63.80	17.2%	$26,317	41	504,637	10,415	61,541	1,270	12	25,432	$0
5	California	83	1,030	24,920	114,340	32,182,118	155,973	456	11,502,870	206	26%	42%	66,100,000	89%	$0	$63.74	16.3%	$41,207	511	387,736	1,879	62,979	305	1	22,511	$0
6	Colorado	11	500 to 999	Withheld	Withheld	3,892,029	103,730	267	1,658,238	38	17%	9%	6,535,000		$0	$39.29	9.3%	$37,168	70	353,821	9,430	55,600	1,482	4	23,689	$0
7	Connecticut	12	160	6,976	22,661	3,267,240	4,845	31	1,301,670	674	23%	23%	3,234,000	100%	$800,000	$22.33	9.9%	$45,486	169	272,270	404	19,333	29	0	7,702	$0.245
8	Delaware	4	0 to 19	Withheld	Withheld	735,143	1,955	57	298,736	376	21%	59%	2,065,000	1%	$4,000,000	$57.29	9.5%	$36,535	3	183,786	489	245,048	652	19	99,579	$5.441
9	Florida	47	913	23,128	92,485	14,677,181	53,997	390	6,337,929	272	40%	28%	24,800,000	57%	$2,722,000	$71.60	13.9%	$30,580	315	312,280	1,149	46,594	171	1	20,120	$0.185
10	Georgia	21	187	5,139	18,001	7,489,982	57,919	536	3,006,369	129	33%		10,236,000		$0	$54.64	14.3%	$34,214	179	356,666	2,758	41,843	324	3	16,795	$0
11	Hawaii	2	0 to 19	Withheld	Withheld	1,192,057	6,423	0	403,240	186	23%	24%	1,884,000	33%	$0	$73.01	12.3%	$30,628	0	596,029	3,212					$0
12	Idaho	1	0 to 19	Withheld	Withheld	1,208,865	82,751	200	469,645	15	10%		1,086,000		$0	$95.83	13.2%	$27,701	6	1,208,865	82,751	201,478	13,792	33	78,274	$0
13	Illinois	30	729	19,262	59,385	11,989,352	55,593	1,279	4,591,779	216	23%	28%	15,102,000	65%	$6,500,000	$23.73	11.1%	$38,045	450	399,645	1,853	26,643	124	3	10,204	$0.542
14	Indiana	12	66	2,321	12,828	5,864,847	35,870	566	2,336,306	164	23%	35%	13,571,000	73%	$3,160,000	$28.44	8.6%	$31,030	169	488,737	2,989	34,703	212	3	13,824	$0.539
15	Iowa	15	89	1,971	9,811	2,854,330	55,875	953	1,149,276	51	30%	35%	2,866,000	66%	$0	$76.89	9.4%	$27,931	574	190,289	3,725	4,973	97	2	2,002	$0
16	Kansas	8	0 to 19	Withheld	Withheld	2,601,437	81,823	627	1,037,891	32	11%	9%	3,000,000	46%	$1,500,000	$60.12	10.1%	$29,361	101	325,180	10,228	25,757	810	6	10,276	$0.577
17	Kentucky	7	218	6,506	18,110	3,910,366	39,732	436	1,590,647	98	18%	30%	4,376,000	15%	$150,000	$61.49	15.5%	$28,800	43	558,624	5,676	90,939	924	10	36,992	$0.038
18	Louisiana	8	203	4,981	23,031	4,353,646	43,566	301	1,656,053	100	15%	17%	3,361,000		$0	$82.20	18.6%	$27,888	33	544,206	5,446	131,929	1,320	9	50,183	$0
19	Maine	25	196	4,854	26,894	1,241,895	30,865	22	518,200	40	33%	40%	1,696,000	37%	$465,000	$94.71	10.6%	$27,664	84	49,676	1,235	14,784	367	0	6,169	$0.374
20	Maryland	10	124	4,204	24,012	5,094,924	9,775	155	1,980,859	521	27%	37%	6,268,000	70%	$0	$59.70	8.6%	$36,395	100	509,492	978	50,949	98	2	19,809	$0
21	Massachusetts	30	563	14,736	62,644	6,114,440	7,838	39	2,443,580	780	33%	38%	8,141,000	78%	$7,000,000	$40.91	10.3%	$44,168	156	203,815	261	39,195	50	0	15,664	$1.145
22	Michigan	32	174	6,216	26,356	9,779,984	56,809	534	3,785,661	172	25%	18%	18,717,000	30%	$260,000	$38.40	10.8%	$37,011	200	305,625	1,775	48,900	284	3	18,928	$0.027
23	Minnesota	21	494	16,188	76,753	4,687,408	79,617	854	1,895,127	59	46%	42%	5,634,000	75%	$14,000,000	$83.90	9.9%	$35,414	771	223,210	3,791	6,080	103	1	2,458	$2.987
24	Mississippi	4	51	338	1,735	2,731,644	46,914	295	1,046,434	58	12%	16%	4,400,000	12%	$500,000	$69.26	18.3%	$25,208	15	682,911	11,729	182,110	3,128	20	69,762	$0.183
25	Missouri	20	72	1,470	7,265	5,408,455	68,898	942	2,194,594	78	26%	38%	10,288,000			$45.46	10.4%	$31,384	197	270,423	3,445	27,454	350	5	11,140	
26	Montana	2	0 to 19	Withheld	Withheld	878,730	145,556	128	358,667	6	5%		757,000		$0	$168.31	16.4%	$24,272	6	439,365	72,778	146,455	24,259	21	59,778	$0
27	Nebraska	3	20 to 99	Withheld	Withheld	1,657,009	76,878	535	666,184	22	26%	23%	1,848,000	29%	$4,000,000	$81.79	10.8%	$27,693	15	552,336	25,626	110,467	5,125	36	44,412	$2.414
28	New Hampshire	10	43	1,026	4,382	1,172,140	8,969	13	474,606	131	20%	21%	1,068,000	41%	$350,000	$27.70	8.4%	$34,736	38	117,214	897	30,846	236	0	12,490	$0.299
29	New Jersey	33	464	10,585	51,234	8,058,384	7,419	320	3,064,645	1,086	43%	38%	9,200,000	90%	$11,300,000	$37.36	9.0%	$43,676	510	244,193	225	15,801	15	1	6,009	$1.402
30	New Mexico	5	26	531	3,076	1,723,965	121,365	98	677,971	14	12%	9%	3,418,000	21%	$0	$49.12	22.4%	$27,498	3	344,793	24,273	574,655	40,455	33	225,990	$0
31	New York	47	583	14,773	73,734	18,146,200	47,224	619	7,056,860	384	32%	42%	31,100,000	95%	$0	$18.88	16.6%	$45,358	1472	386,089	1,005	12,328	32	0	4,794	$0
32	North Carolina	22	690	15,373	73,177	7,430,675	48,718	511	3,132,013	153	22%	26%	13,500,000	46%	$1,300,000	$59.89	12.5%	$31,068	271	337,758	2,214	27,419	180	2	11,557	$0.175
33	North Dakota	3	20 to 99	Withheld	Withheld	640,965	68,994	366	257,152	9	27%	11%	573,000	16%	$50,000	$130.32	13.2%	$24,683	25	213,655	22,998	25,639	2,760	15	10,286	$0.078
34	Ohio	23	680	19,017	66,866	11,192,932	40,953	941	4,445,773	273	15%	21%	14,335,000		$0	$27.56	11.6%	$32,508	372	486,649	1,781	30,089	110	3	11,951	$0
35	Oklahoma	7	58	1,492	11,379	3,321,611	68,679	592	1,342,293	48	12%	1%	3,787,000	31%	$200,000	$45.82	14.8%	$26,988	8	474,516	9,811	415,201	8,585	74	167,787	$0.060
36	Oregon	9	164	2,255	13,062	3,243,272	96,003	241	1,333,723	34	29%	39%	4,544,000	77%	$815,000	$80.56	12.8%	$32,776	122	360,364	10,667	26,584	787	2	10,932	$0.251
37	Pennsylvania	30	268	6,129	27,012	12,011,278	44,820	1,022	4,777,003	268	20%	33%	11,620,000	72%	$74,085,000	$42.10	11.3%	$34,015	879	400,376	1,494	13,665	51	1	5,435	$6.168
38	Rhode Island	3	20 to 99	Withheld	Withheld	987,263	1,045	8	408,424	945	23%	24%	1,561,000	85%	$0	$38.19	11.8%	$32,615	26	329,088	348	37,972	40	0	15,709	$0
39	South Carolina	8	65	2,594	14,742	3,788,119	30,111	270	1,533,854	126	27%	31%	4,483,000	42%	$5,051,000	$48.30	13.3%	$28,179	186	473,515	3,764	20,366	162	1	8,247	$1.333
40	South Dakota	5	29	363	2,761	737,755	75,898	310	290,245	10	38%		514,000		$673,000	$108.03	13.0%	$24,802	3	147,551	15,180	245,918	25,299	103	96,748	$0.912
41	Tennessee	12	153	3,503	19,166	5,371,693	41,220	336	2,232,905	130	40%	34%	5,200,000		$0	$32.58	14.5%	$30,557	35	447,641	3,436	153,477	1,178	10	63,797	$0
42	Texas	44	529	9,458	57,773	19,385,699	261,914	1,171	7,393,354	74	14%	35%	44,791,000	25%		$32.52	16.1%	$34,943	159	440,584	5,953	121,923	1,647	7	46,499	
43	Utah	1	20 to 99	Withheld	Withheld	2,065,001	82,168	228	701,281	25	19%	5%	2,433,000		$0	$63.24	8.5%	$29,229	14	2,065,001	82,168	147,500	5,869	16	50,092	$0
44	Vermont	1	0 to 19	Withheld	Withheld	588,632	9,249	51	240,634	64	30%	33%	578,000	55%	$366,000	$108.63	10.6%	$28,914	80	588,632	9,249	7,358	116	1	3,008	$0.622
45	Virginia	15	133	3,150	11,523	6,737,489	39,598	229	2,699,173	170	35%	29%	10,661,000	16%	$1,600,000	$21.89	11.3%	$35,172	79	449,166	2,640	85,285	501	3	34,167	$0.237
46	Washington	19	294	9,651	70,869	5,614,151	66,582	266	2,271,398	84	39%	35%	7,072,000	82%	$0	$87.63	10.0%	$37,099	102	295,482	3,504	55,041	653	3	22,269	$0
47	West Virginia	6	24	493	3,440	1,815,231	24,087	230	736,481	75	13%	25%	1,500,000		$1,300,000	$77.61	17.6%	$26,888	75	302,539	4,015	24,203	321	3	9,820	$0.716
48	Wisconsin	27	262	4,846	17,261	5,201,226	54,314	583	2,084,544	96	40%	36%	3,710,000	60%	$28,342,000	$59.08	8.6%	$30,694	600	192,638	2,012	8,669	91	1	3,474	$5.449
49	Wyoming	1	0 to 19	Withheld	Withheld	480,043	97,105	97	193,608	5	4%	10%	568,000	4%	$0	$248.40	12.0%	$26,836	2	480,043	97,105	240,022	48,553	49	96,804	$0
Other not listed =													3,856,000													

State MSW Recycling Rates: Exploratory Scatter Plots

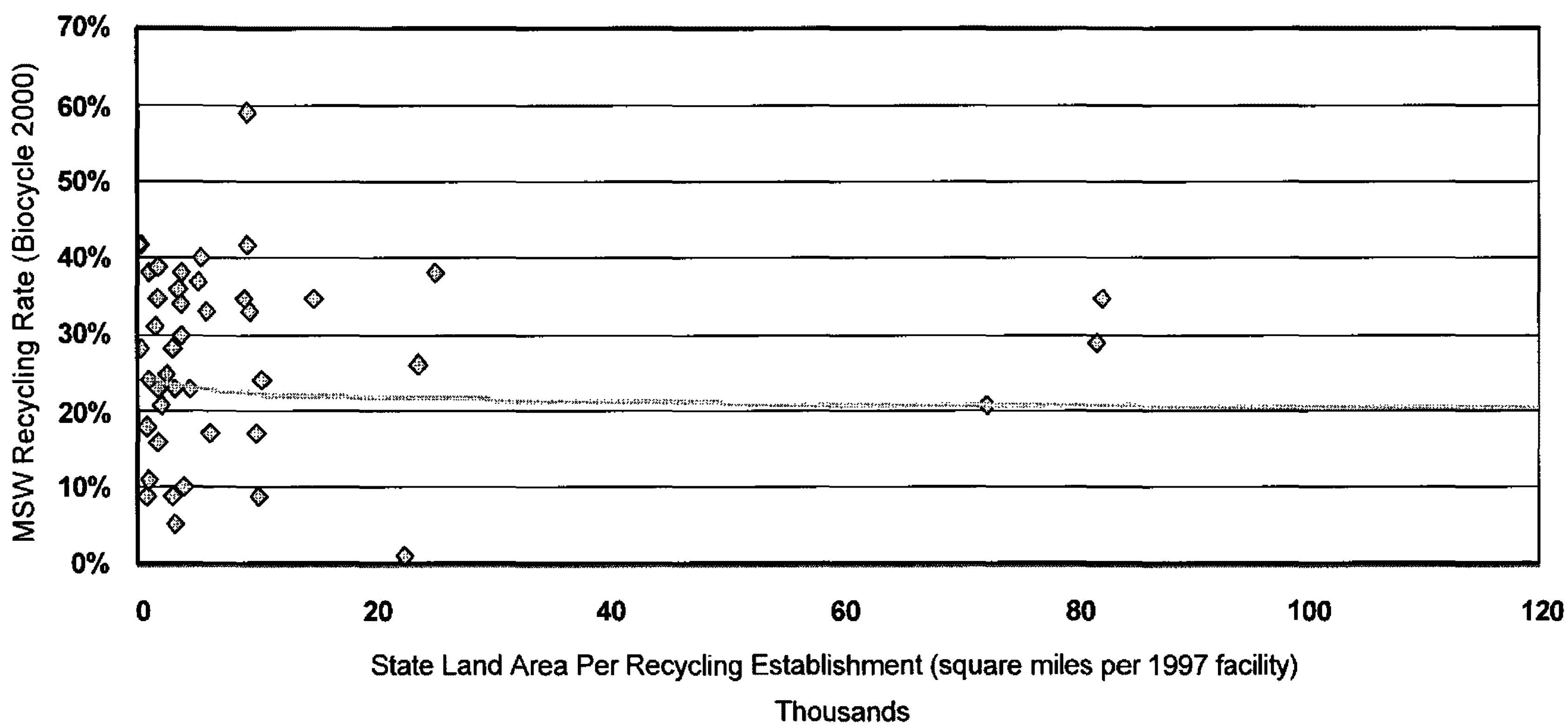


State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)

State MSW Recycling Rates Compared to Land Area Per Recycling Establishment

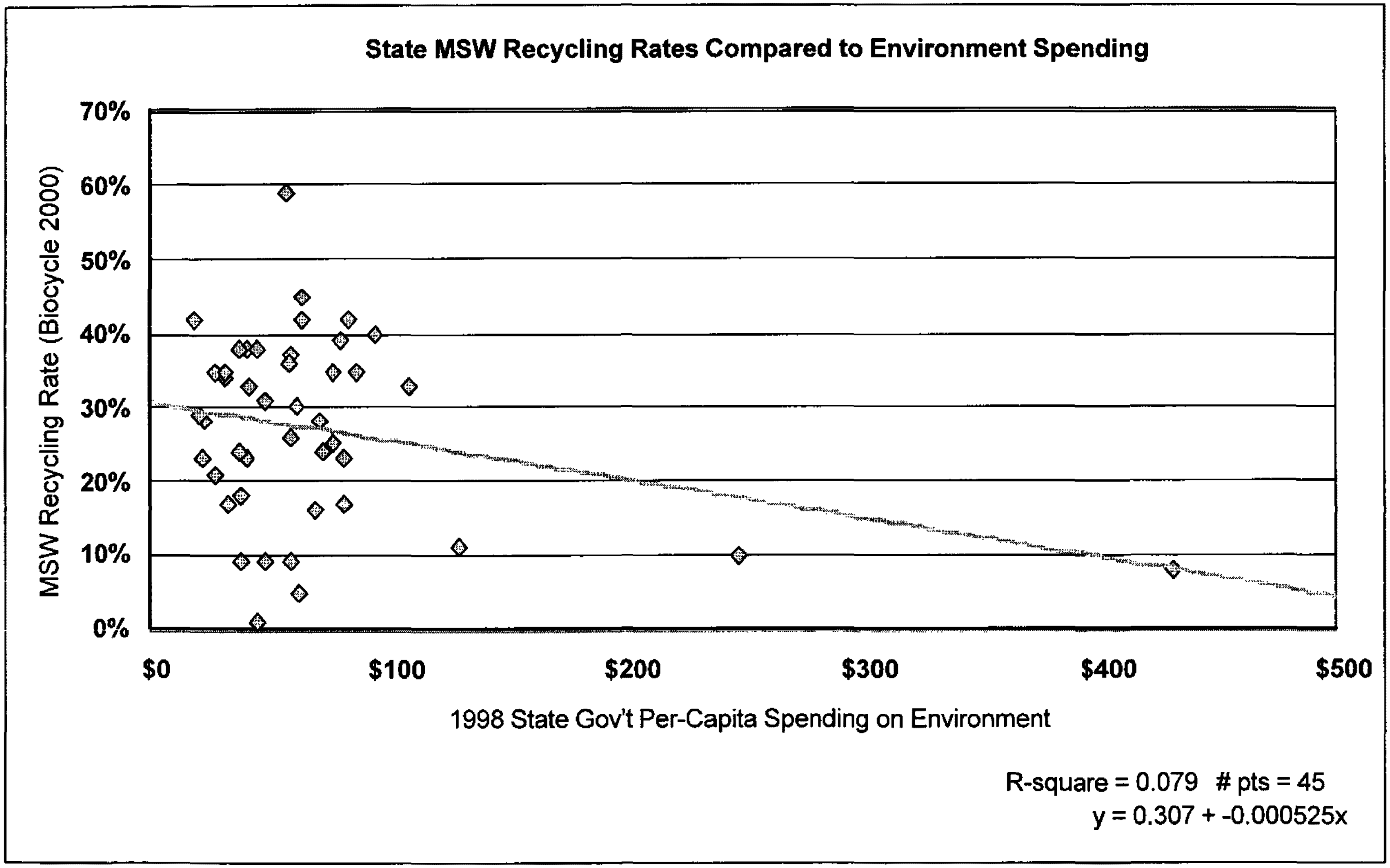


R-square = 0.00517 # pts = 43

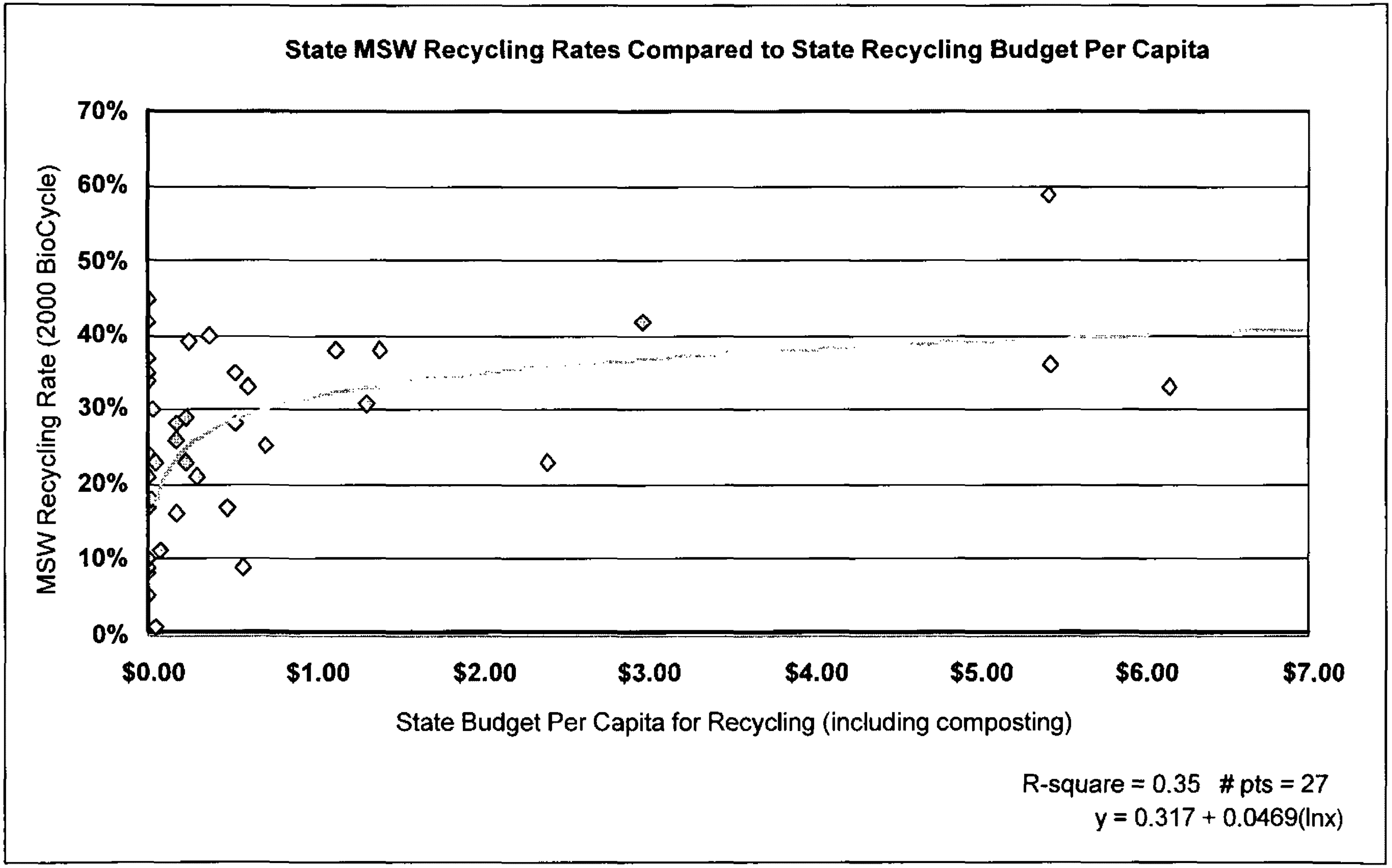
y = 0.316x^-0.0377

Data in this graph exclude Alaska (1 recycling establishment)

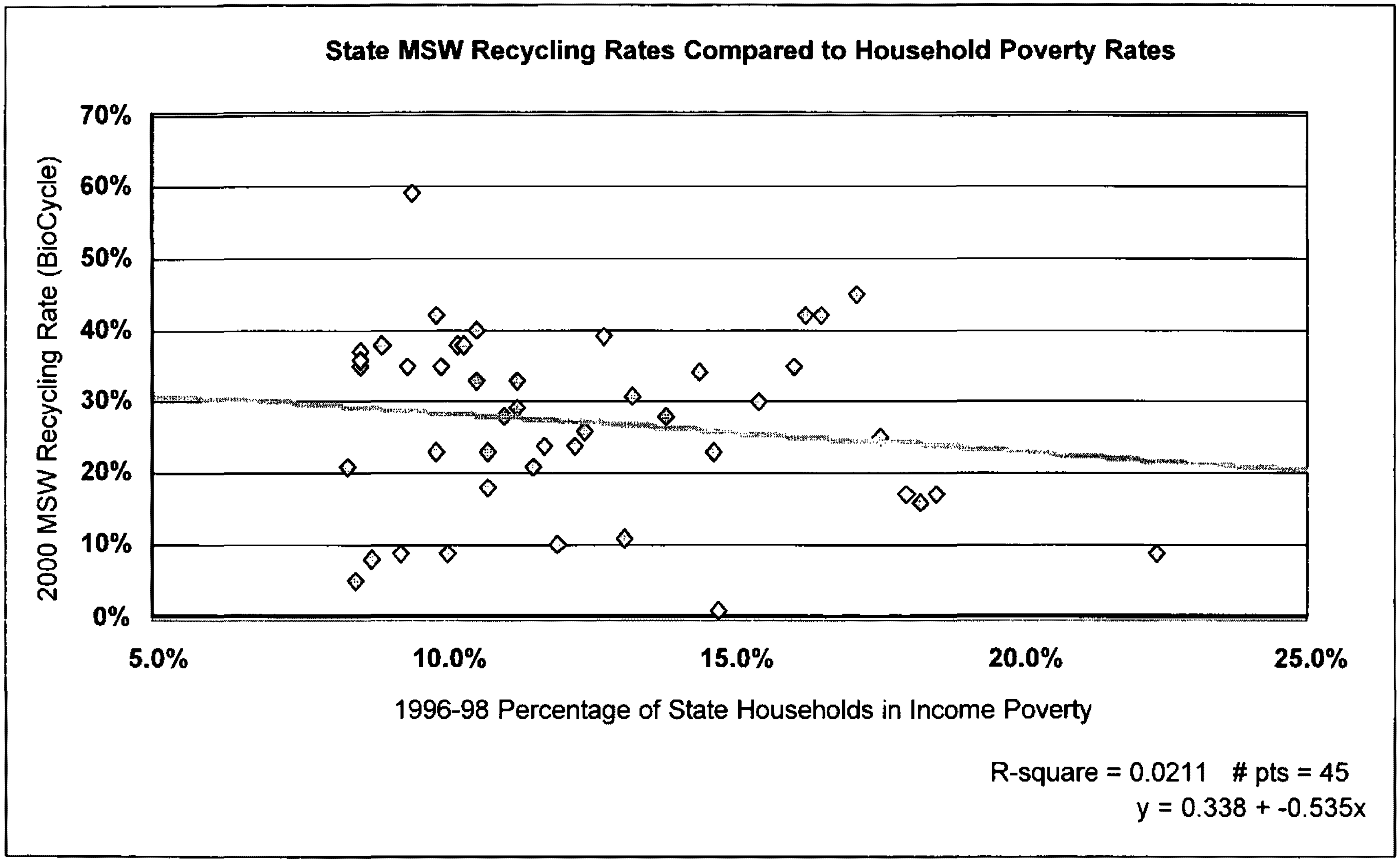
State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



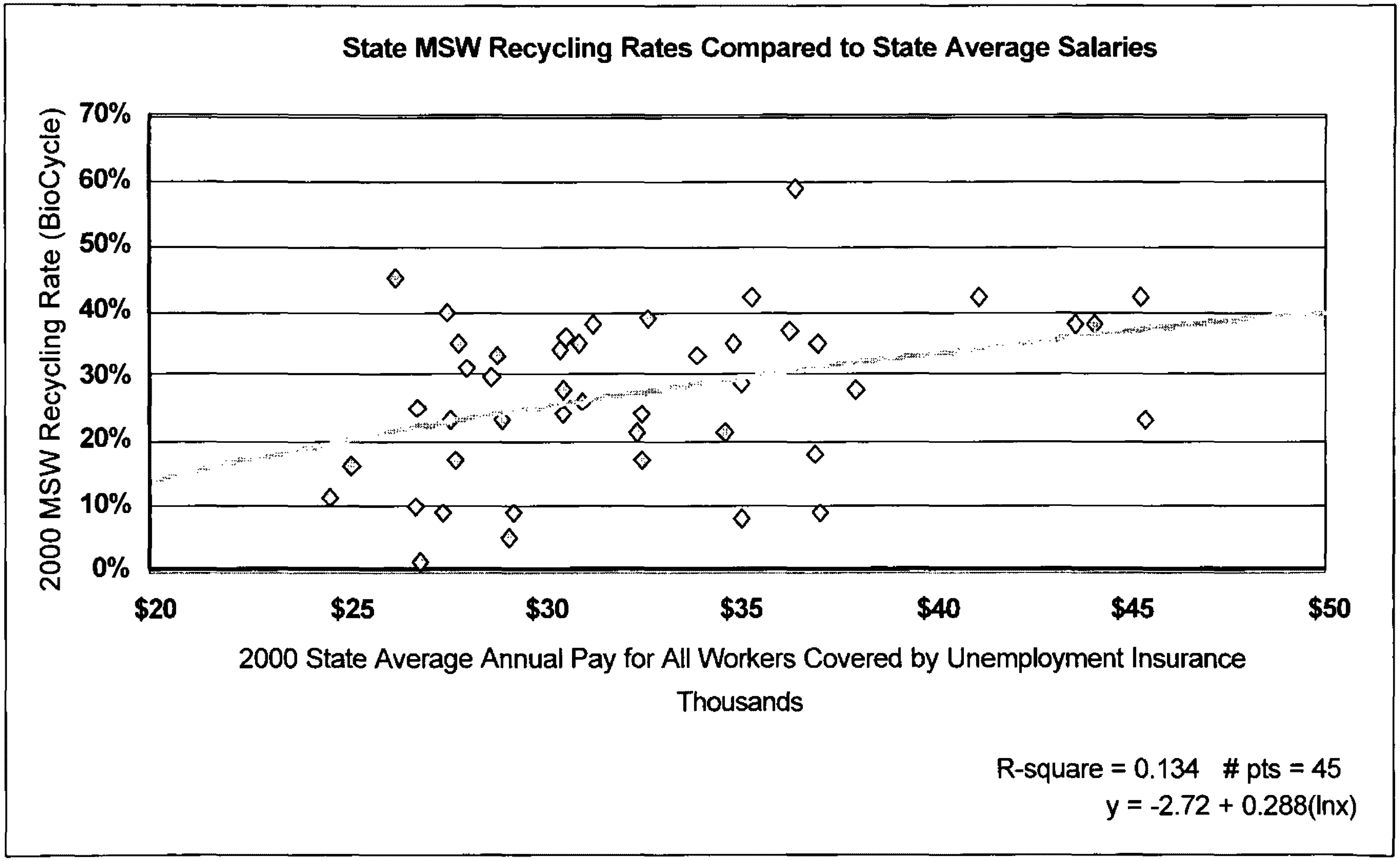
State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



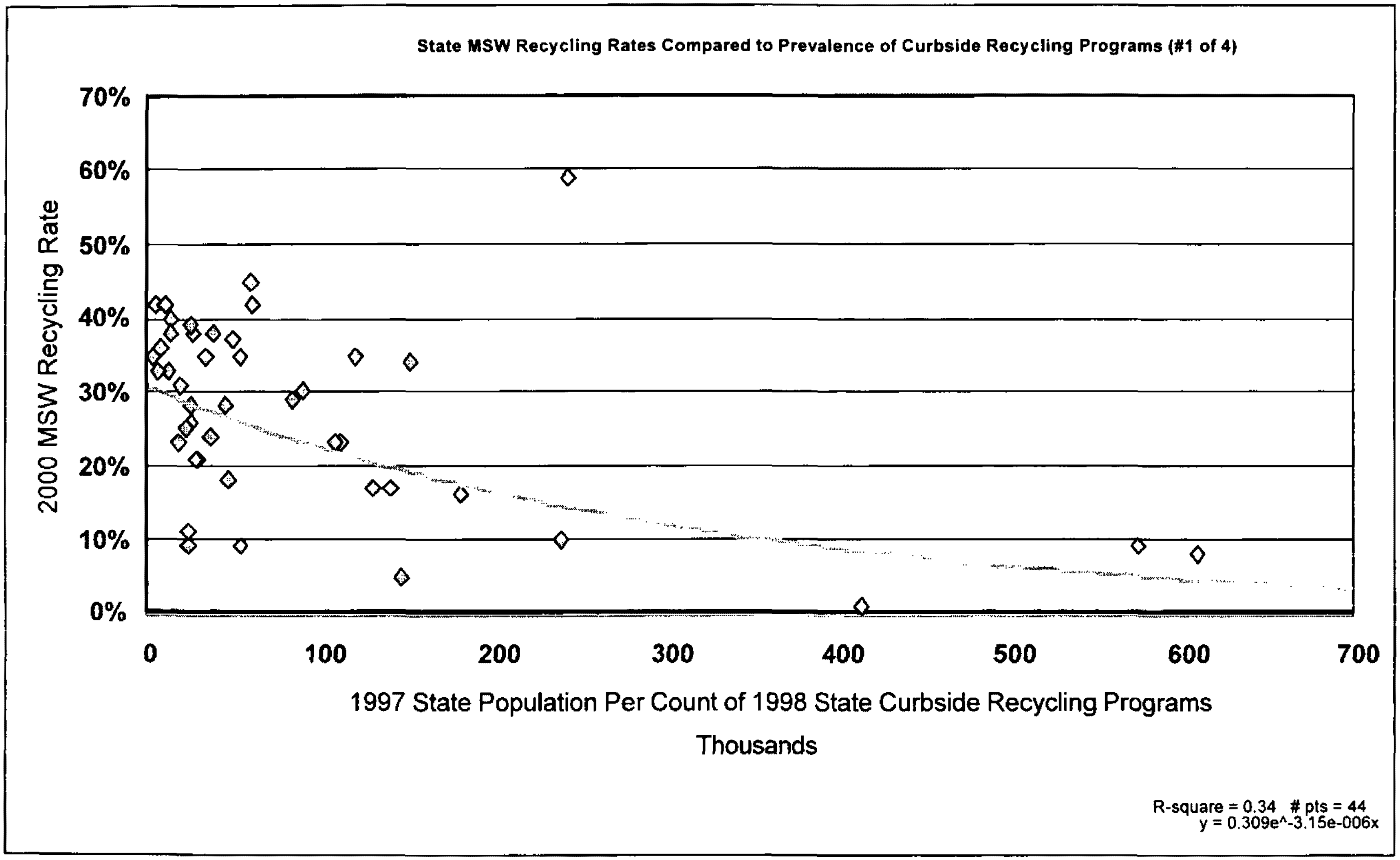
State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



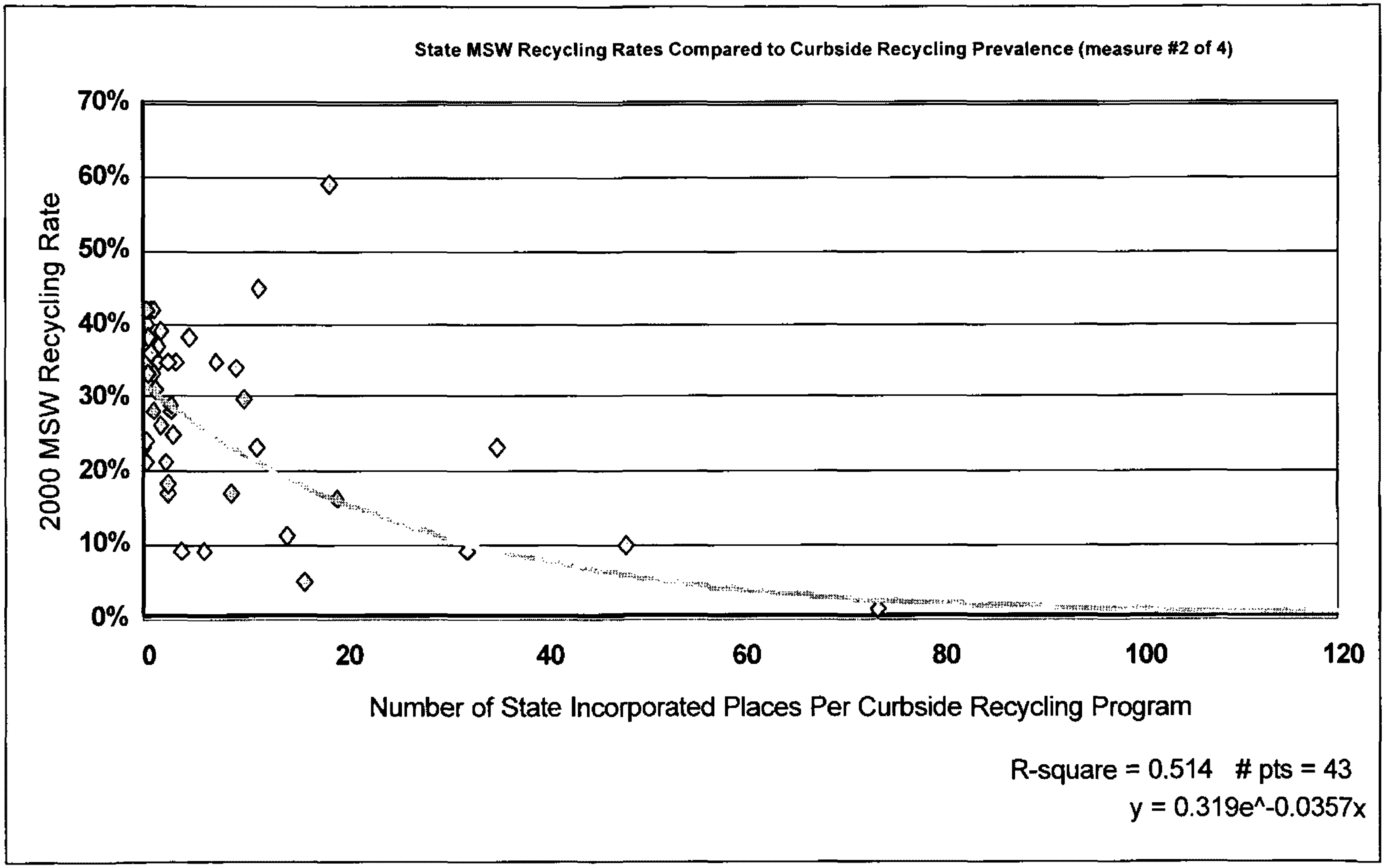
State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



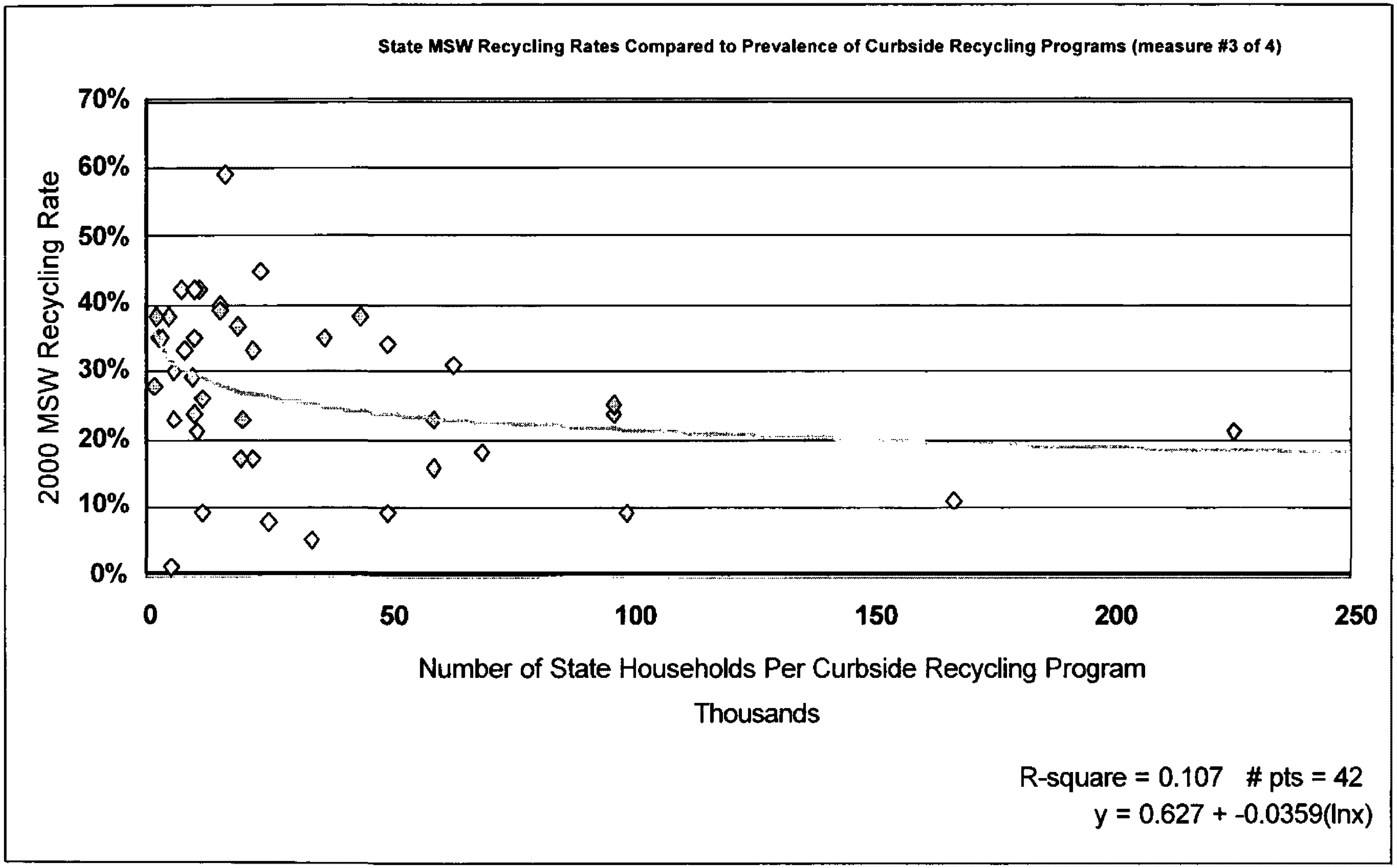
State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



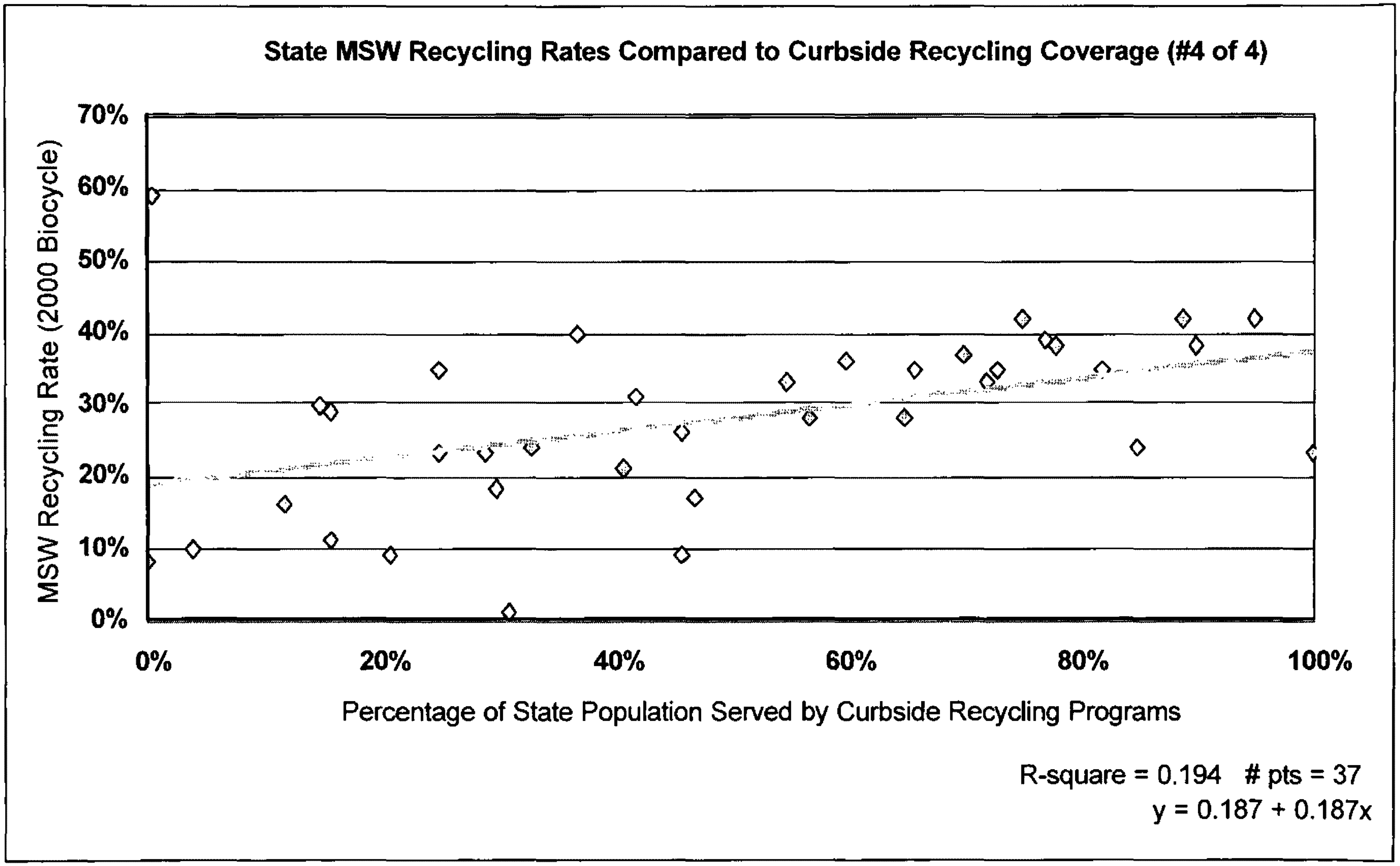
State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



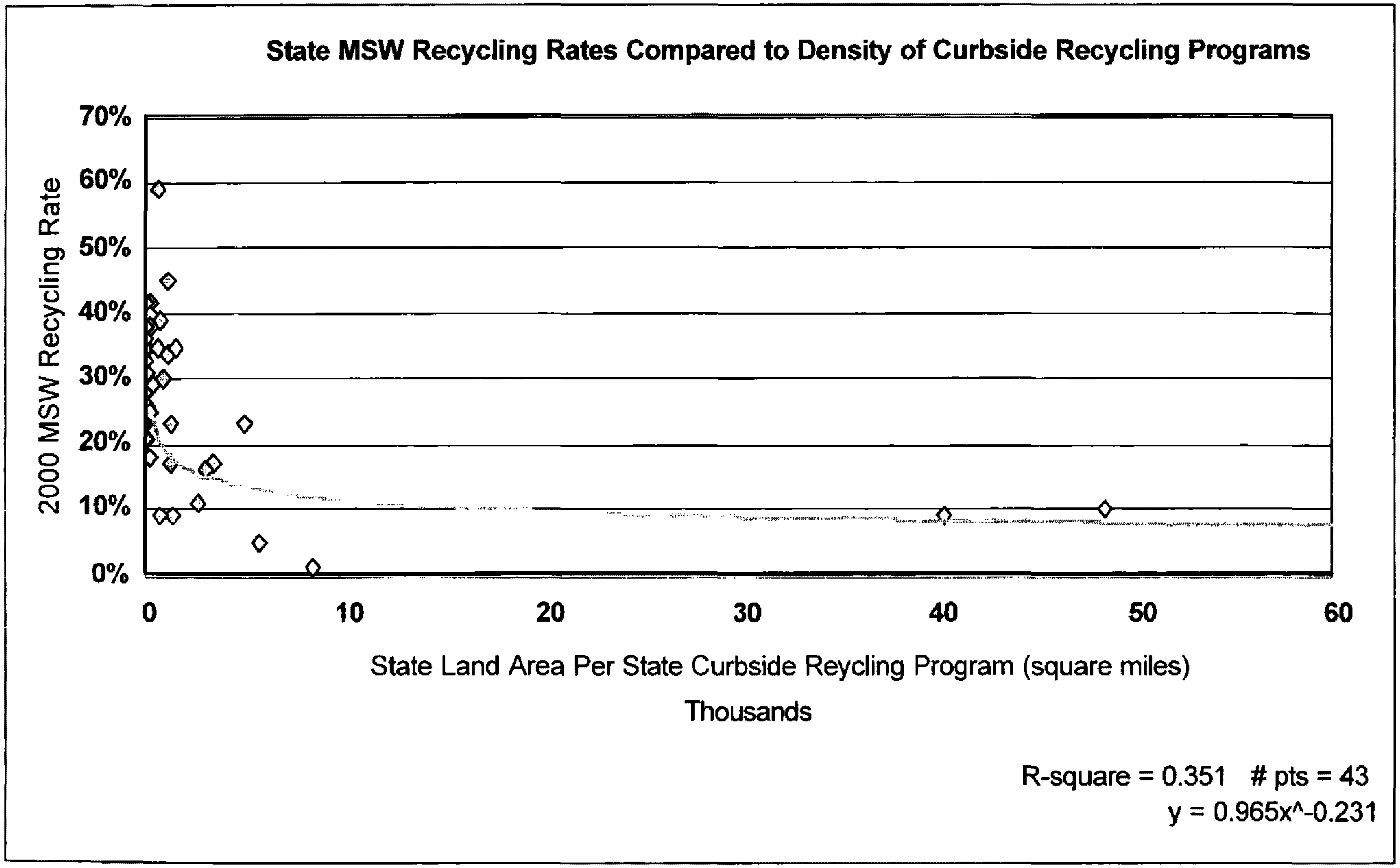
State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



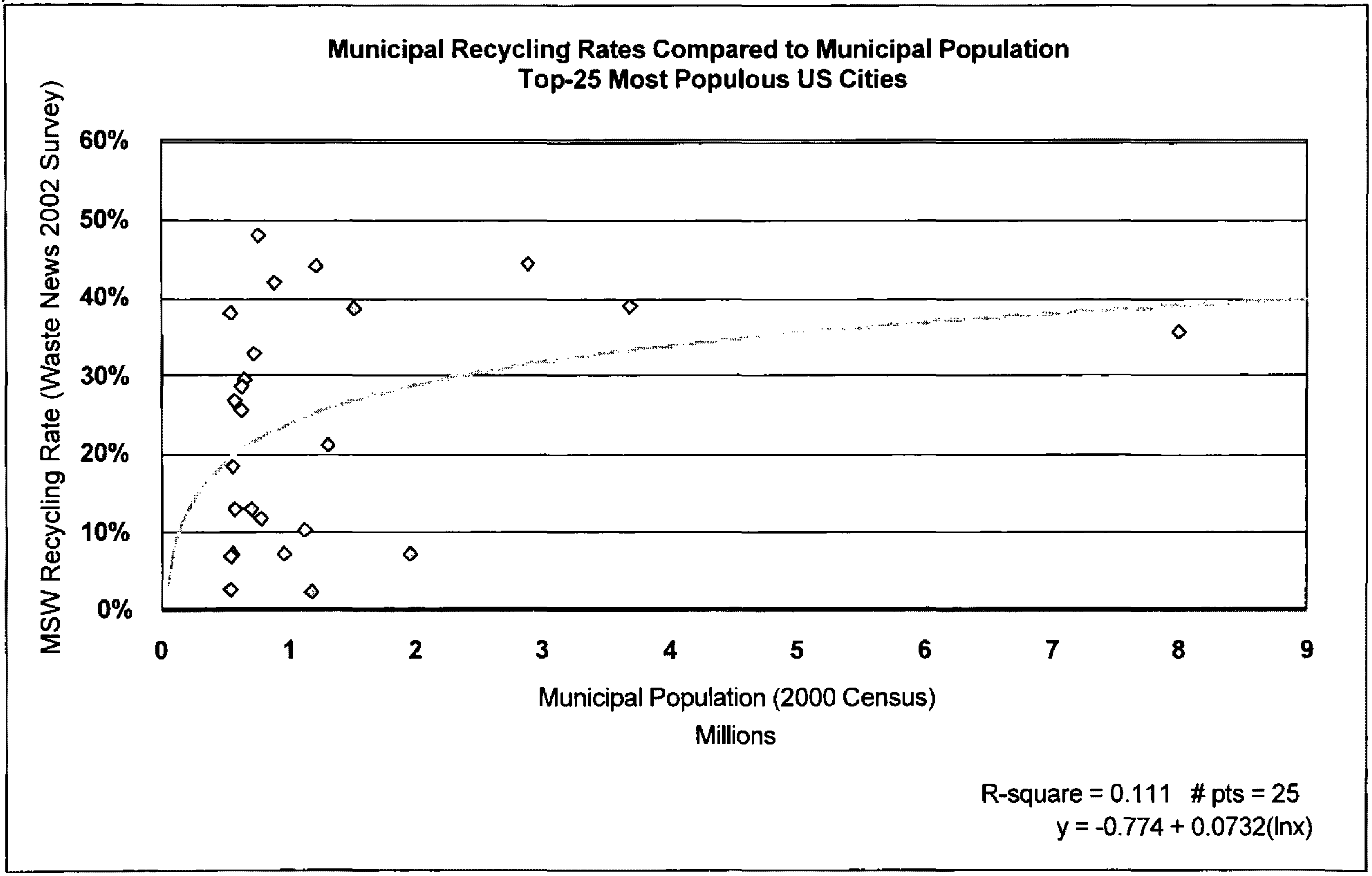
Appendix B: Municipality Recycling Rates & Infrastructure (exploratory X-Y plot graphs based on two separate data sets)

Municipality Recycling Dataset (Top-25 Most Populous Cities)

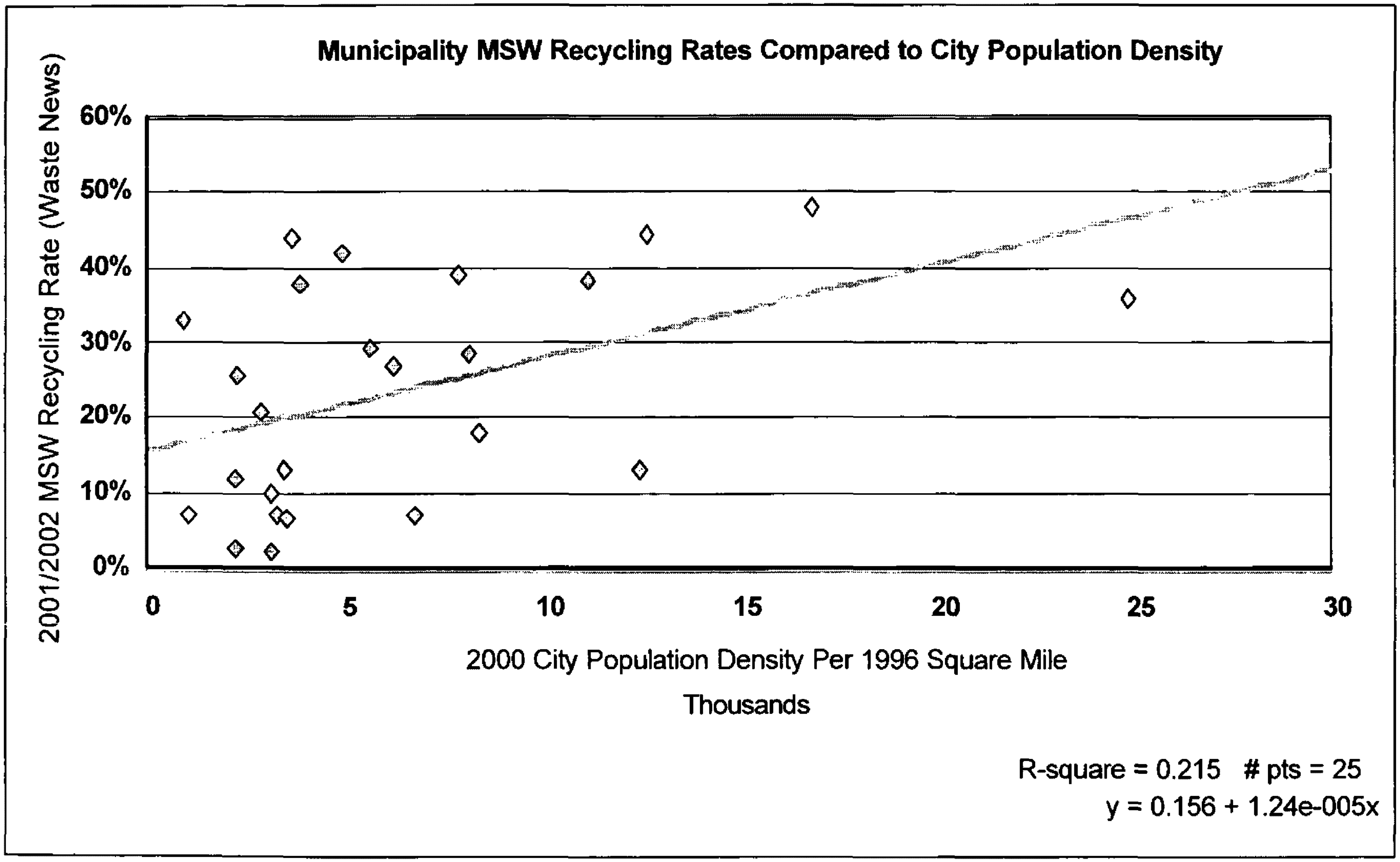
Estimate of US National Average MSW Recycling Collection Cost & Recyclable Materials Revenues (source: Waste News 2003 Survey)

		A	B	C	D (B/C)	E	F (B/E)	G (C/E)	H	I	J	K	L (J/K)	M	N (M/K)
Item	Top-25 most populous municipalities	Waste News 2003 survey MSW recycl rate for 2001/2002	City population 2000	Land area (sq.miles) 1996	Population density	Nr. of dropoff sites	Population per drop off sites	Land area per drop off sites	Amount spent on recycling per resident	Recycling budget as % of solid waste budget	Recycling budget ($/year)	Recycling volume (tons/year)	2001/2002 recycling avg cost ($/ton)	Recycling materials revenue ($/year)	Recycling revenue avg value ($/ton)
1	San Francisco	48.0%	776,733	46.1	16,849	20	38,837	2	$2.87		$2,231,988	825,000	$3	$10,603	$0.01
2	Chicago	44.3%	2,896,016	228.5	12,674	10	289,602	23				2,146,321		$0	$0
3	San Diego	44.0%	1,223,400	330.7	3,699	55	22,244	6	$15.04	23.4%	$18,400,000	98,270	$187	$1,858,363	$18.91
4	San Jose	42.0%	894,943	180.8	4,950							636,000			
5	Los Angeles	39.0%	3,694,820	467.4	7,905	1	3,694,820	467	$11.48	50.7%	$42,400,000	664,045	$64	$1,654,730	$2.49
6	Philadelphia	38.5%	1,517,550	136.0	11,158	3	505,850	45	$5.34	9.3%	$8,100,000	38,551	$210	$94,830	$2.46
7	Seattle	37.9%	563,374	144.6	3,896	2	281,687	72				43,919			
8	New York	35.7%	8,008,278	321.8	24,886	4	2,002,070	80	$12.92	9.9%	$103,438,905	5,960,496	$17	$5,960,778	$1.00
9	Jacksonville	33.0%	735,617	759.6	968							506,229		$1,600,000	$3.16
10	Austin	29.5%	656,562	116.0	5,660	1	656,562	116	$7.75	12.6%	$5,090,621	51,726	$98	$1,388,220	$26.84
11	Baltimore	28.7%	651,154	80.3	8,109	6	108,526	13	$1.36	1.5%	$887,148	29,475	$30		
12	Milwaukee	26.8%	596,974	95.8	6,231	2	298,487	48	$9.05	25.2%	$5,400,000	65,770	$82		
13	Memphis	25.6%	650,100	277.0	2,347	3	216,700	92	$2.00	3.0%	$1,300,000	104,087	$12	$366,988	$3.53
14	Phoenix	21.0%	1,321,045	456.7	2,893	3	440,348	152	$3.47	9.4%	$4,583,286	111,521	$41	$4,200,000	$37.66
15	Wash DC	18.2%	572,059	68.3	8,382	1	572,059	68	$6.44		$3,683,509	27,360	$135	$15,942	$0.58
16	Columbus	13.0%	711,470	203.3	3,500	49	14,520	4	$2.95	6.4%	$2,100,840	51,605	$41		
17	Boston	13.0%	589,141	47.2	12,482	1	589,141	47	$5.94	9.2%	$3,500,000	38,100	$92	$165,000	$4.33
18	Indianapolis	11.8%	791,926	362.0	2,250	27	29,331	13	$1.50	3.1%	$1,188,000	34,456	$34	$1,511	$0.04
19	San Antonio	10.1%	1,144,646	360.0	3,180	3	381,549	120	$3.38	20.4%	$3,863,405	46,037	$84	$600,525	$13.04
20	Detroit	7.2%	970,196	143.0	6,785	1	970,196	143				42,649			
21	Nashville	7.0%	569,891	533.0	1,069	12	47,491	44	$14.79	25.8%	$8,429,863			$200,000	
22	Houston	7.0%	1,953,631	594.0	3,289	12	162,803	50	$2.05	6.7%	$4,000,000	32,144	$124	$550,000	$17.11
23	Denver	6.7%	554,636	154.6	3,588				$3.59	10.1%	$1,991,792	16,534	$120	$735,000	$44.45
24	El Paso	2.5%	563,662	247.4	2,278	15	37,577	16	$2.13	5.1%	$1,201,229	7,191	$167	$230,796	$32.10
25	Dallas	2.2%	1,188,580	378.0	3,144	39	30,476	10	$2.04	4.8%	$2,426,604	14,033	$173		
	Mean =	23.7%			6,487		517,767	74	$5.80	13.1%		Mean =	$90		$12.22
	Median =	25.6%			3,896		285,644	48	$3.53	9.4%		Median =	$84		$3.53
	Pop-wtd avg =	28.7%										Tons-wtd avg =	$19		$1.68
	Data points =	25			25	22	22	22	20	18	20	24	19	18	17

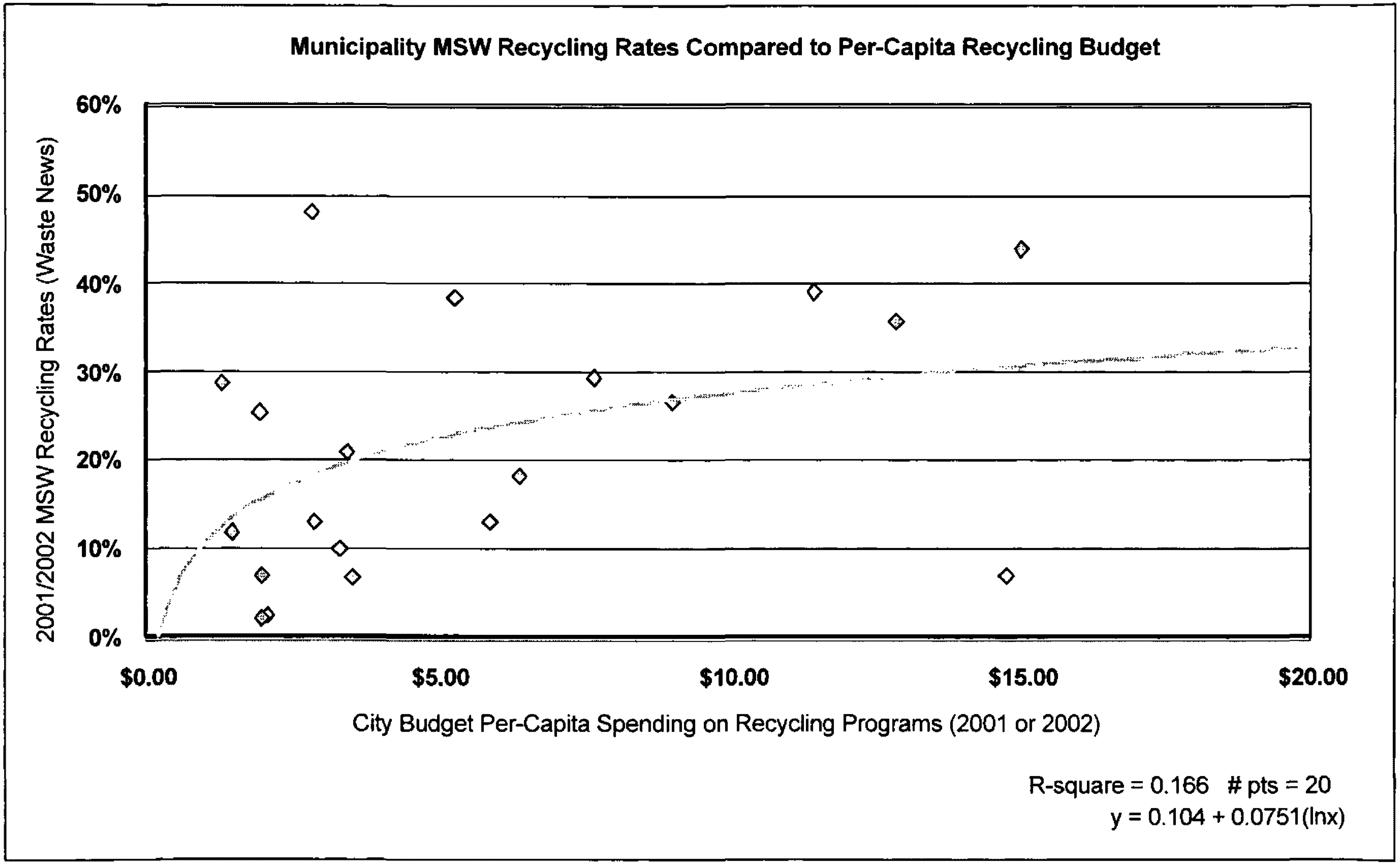
Municipality MSW Recycling Rates: Exploratory Scatter Plots



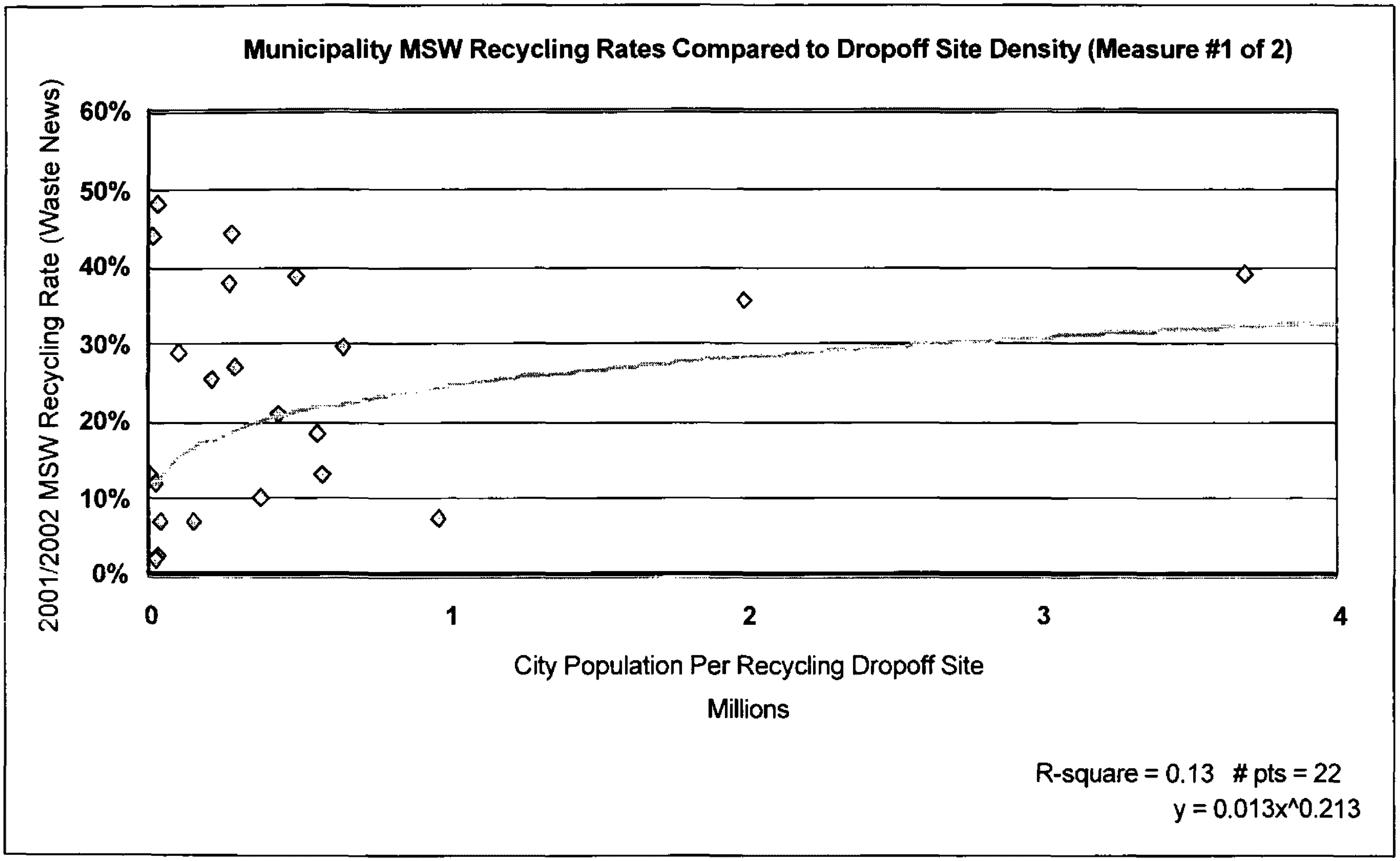
Municipality MSW Recycling Rates: Exploratory Scatter Plots



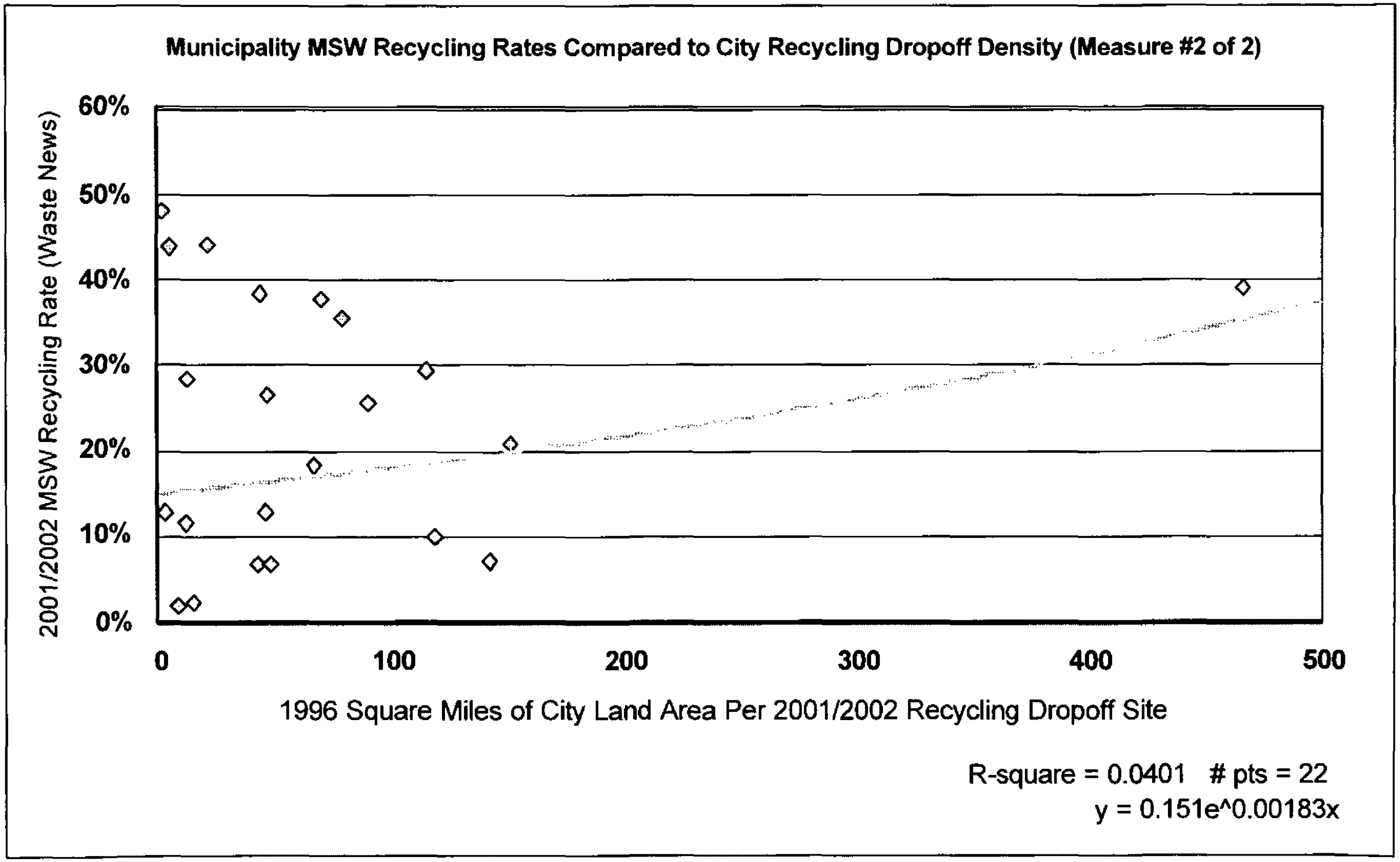
Municipality MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



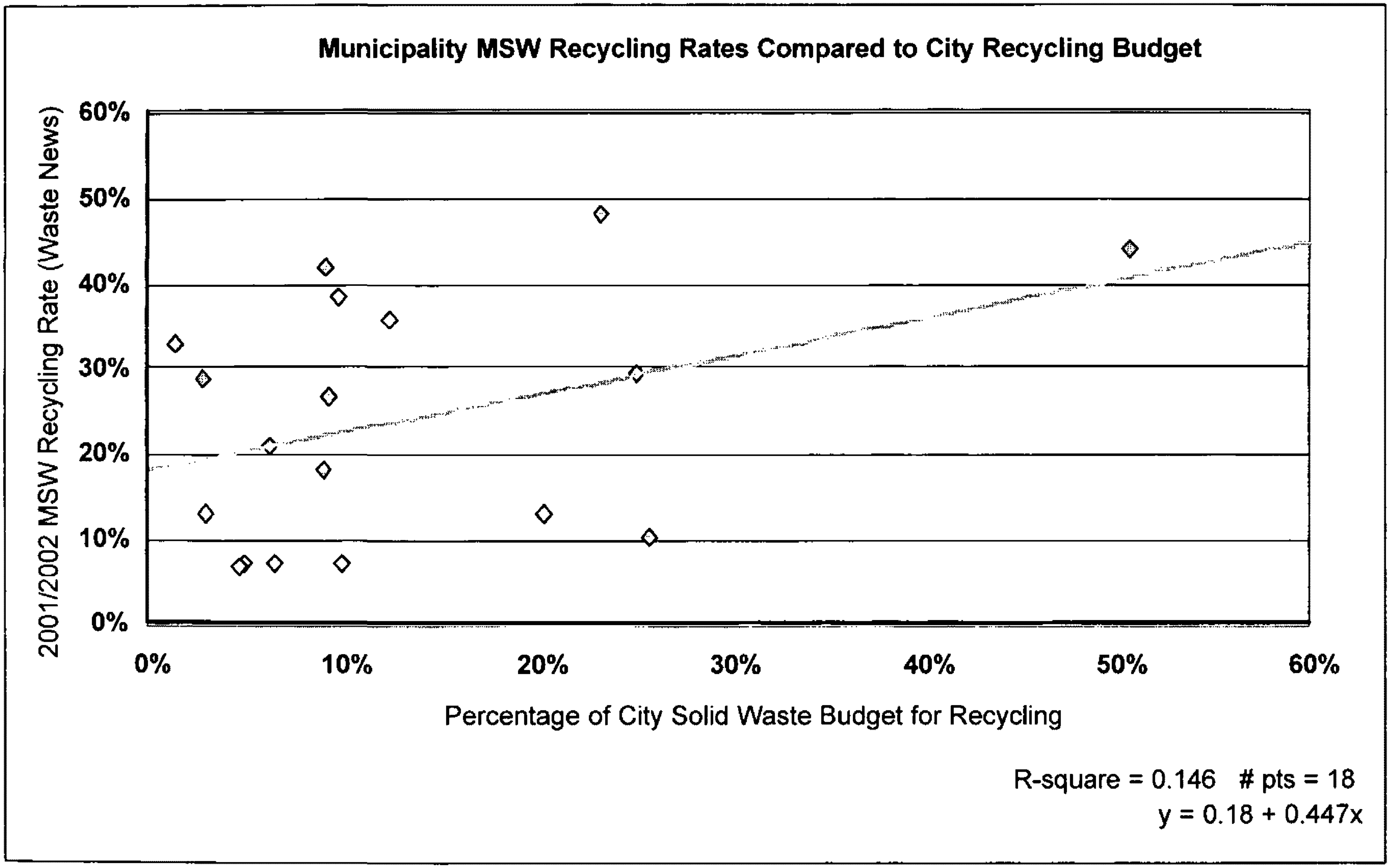
Municipality MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



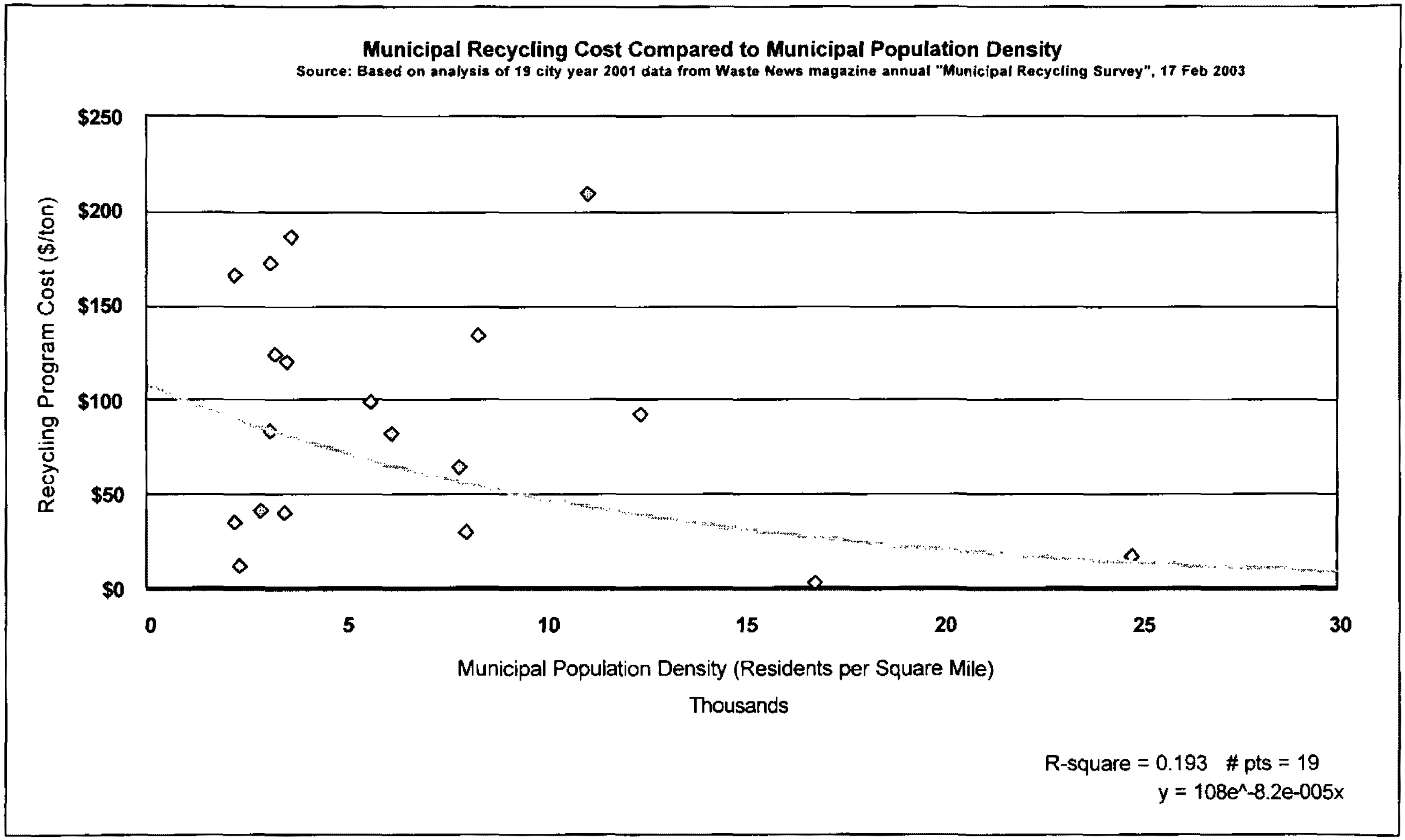
Municipality MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



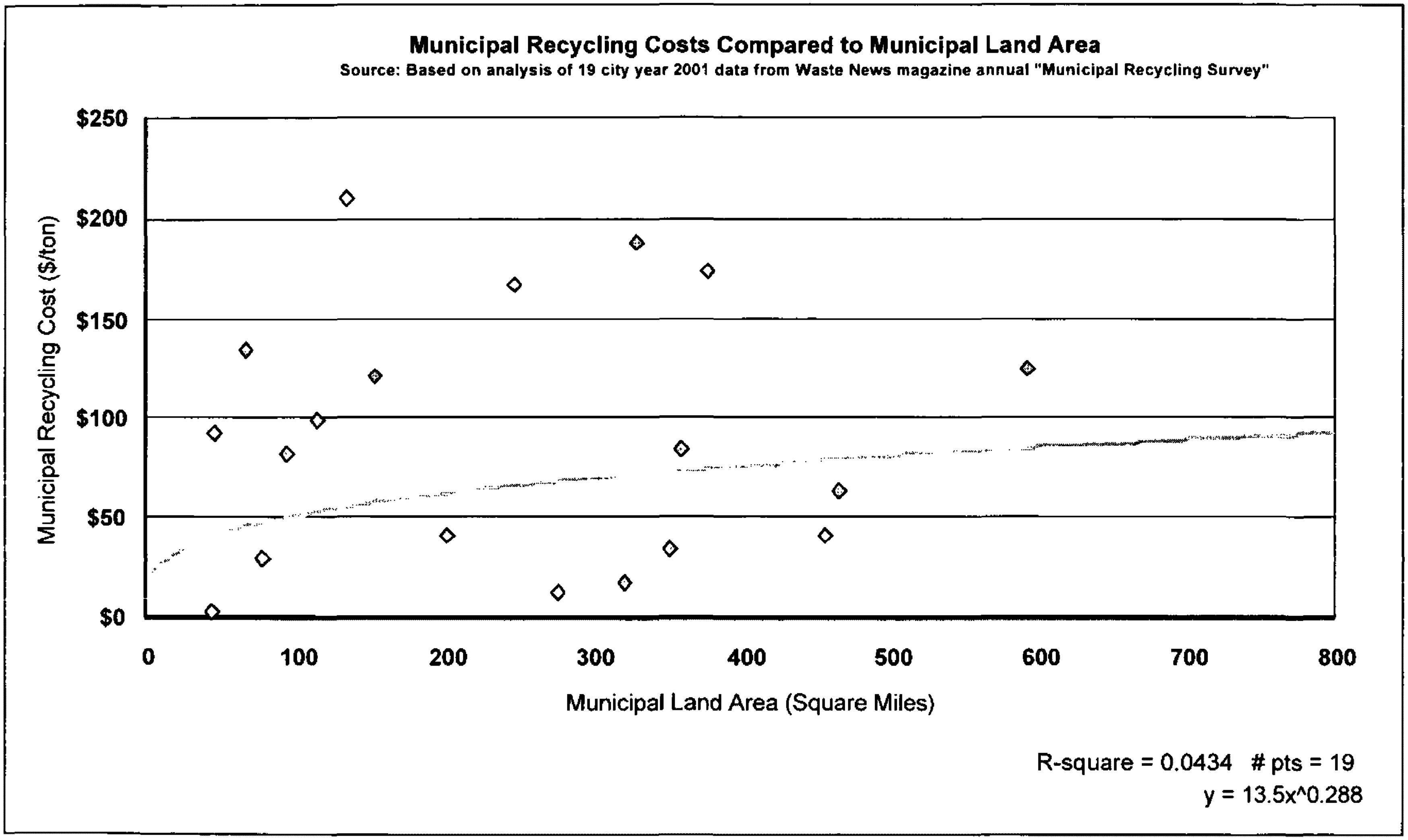
Municipality MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



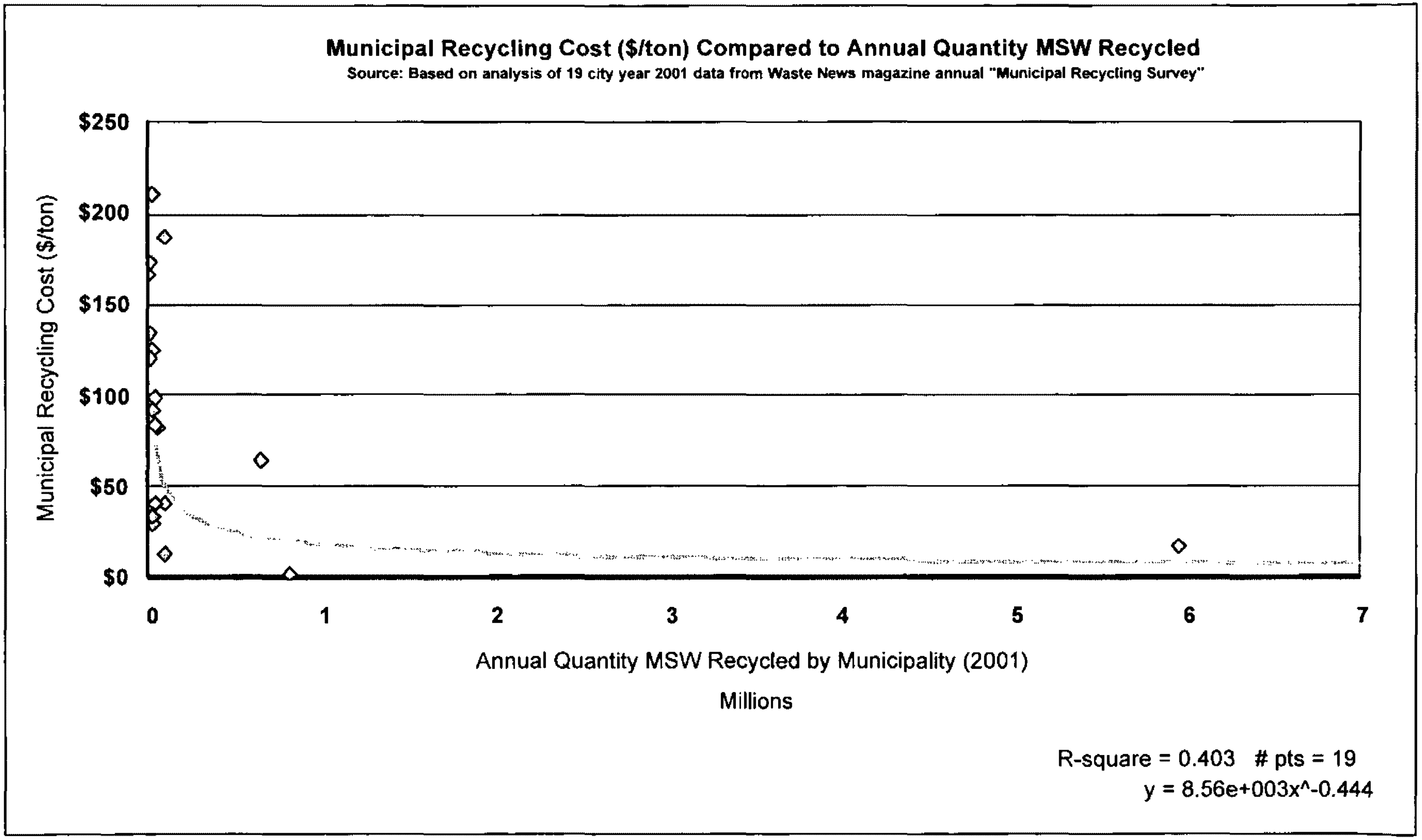
Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Population Density (n=19 municipality sample 2001)



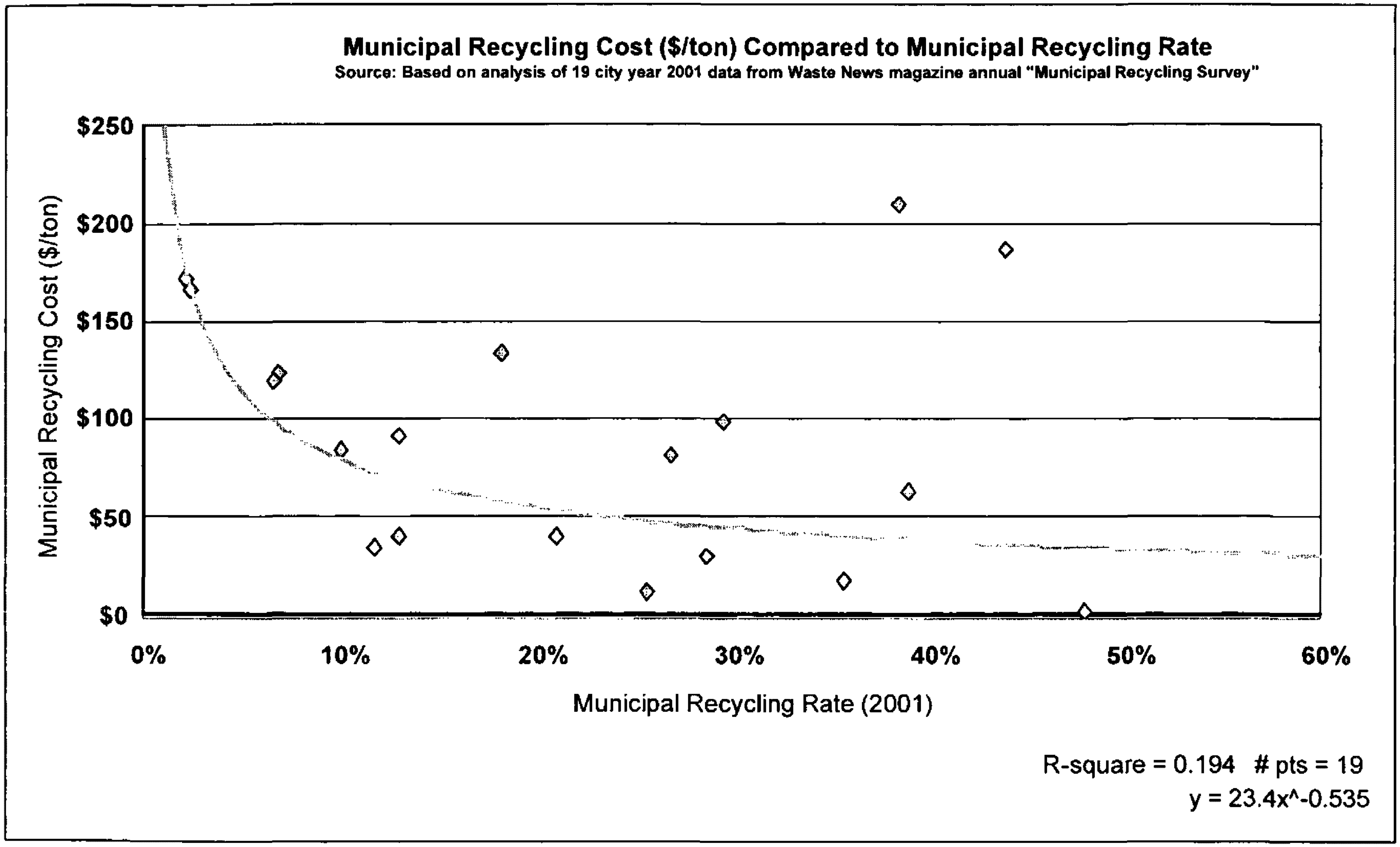
Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Land Area (n=19 municipality sample 2001)



Exploratory Comparison Between Average Recycling Cost ($/ton) & Annual Quantity Recycled (n=19 municipality sample 2001)



Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Recycling Rate (n=19 municipality sample 2001)

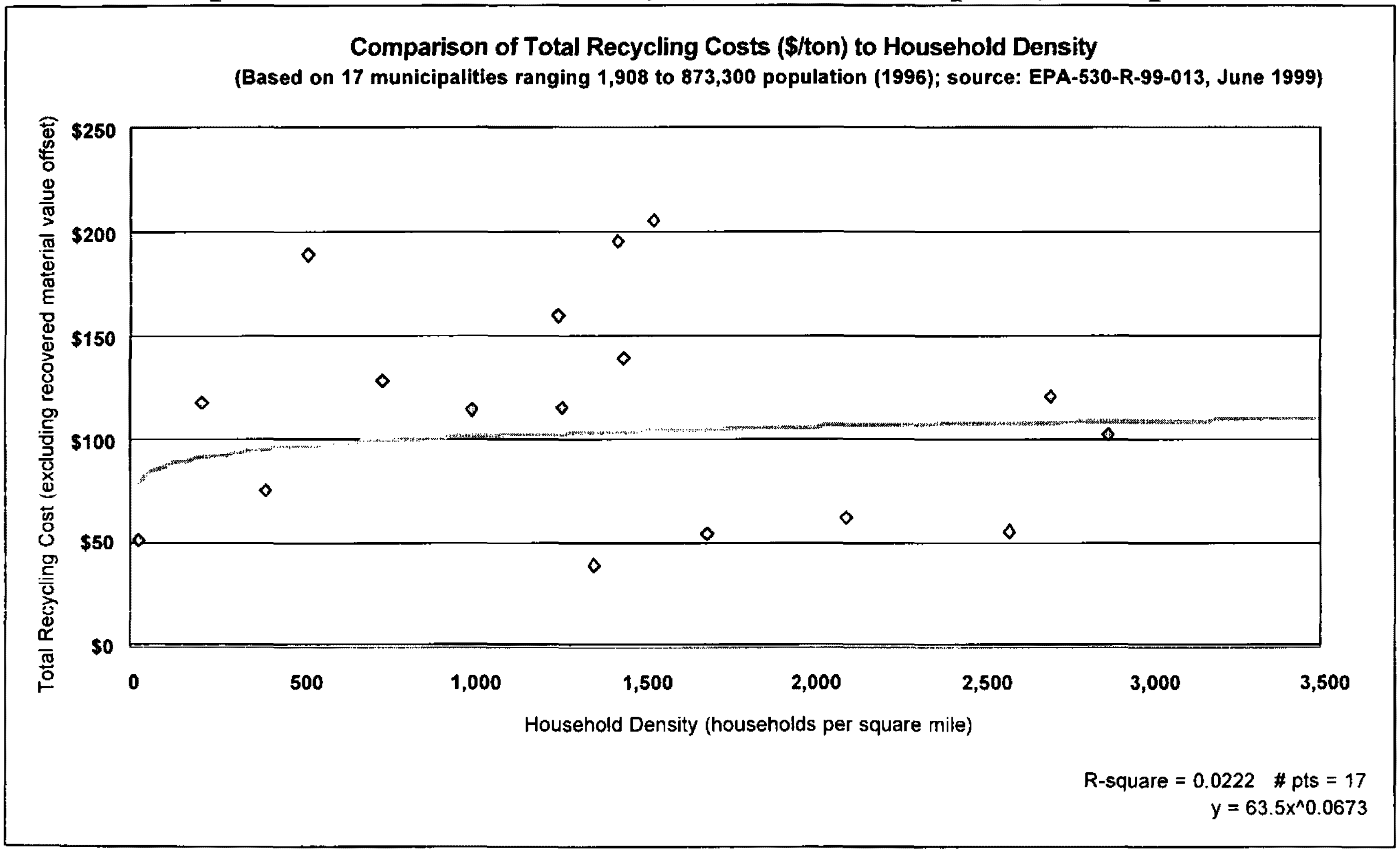


17 City Dataset from 1999 USEPA Study

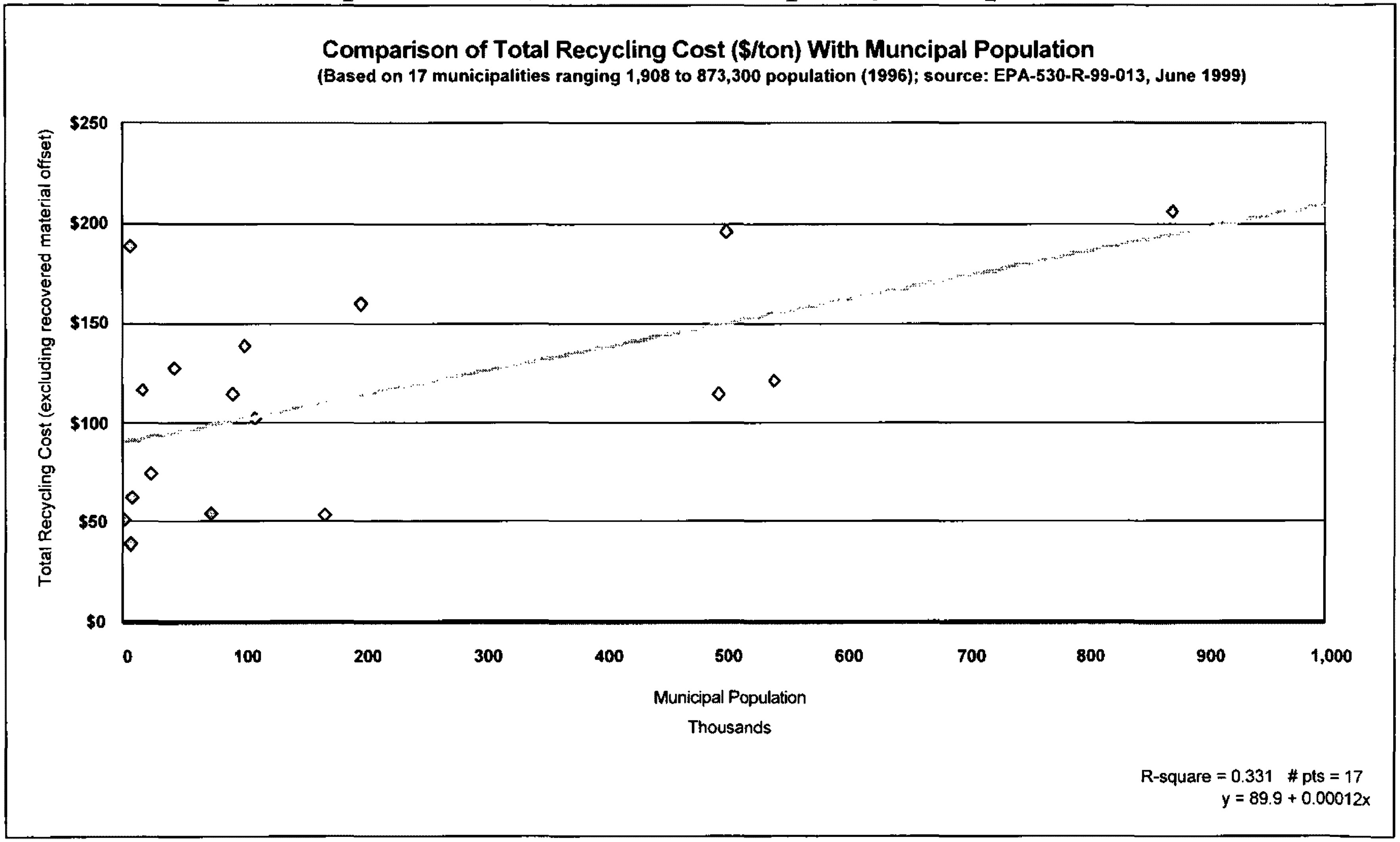
17 Cities in MSW Recycling Cost Dataset from EPA-530-R-99-013, June 1999 (1996$)

Item	City	State	A 1996 population	B Household density (per sq.mile)	C Recycling collection ($/ton)	D Recycling processing ($/ton)	E (F-C-D) Recycling admin/OH ($/ton)	F Recycling total cost ($/ton)	G Materials revenues ($/ton)	H (F-G) Recycling net cost ($/ton)
1	Ann Arbor	MI	112,000	2,875	$73	$14	$15	$101.85	$9.07	$93
2	Bellevue	WA	103,700	1,451			$10	$139.13	$0	$139
3	Chatham	NJ	8,007	1,363			$1	$38.72	$7.98	$31
4	Clifton	NJ	75,000	2,583	$46	$1	$8	$54.61	$4.81	$50
5	Crockett	TX	8,300	523	$14	$100	$75	$188.91	$17.01	$172
6	Dover	NH	25,042	400			$8	$75.00	$0	$75
7	Falls Church	VA	10,000	2,108			$21	$62.00	$0	$62
8	Fitchburg	WI	17,266	216			$36	$117.00	$0	$117
9	Leverett	MA	1,908	28	$7	$0	$44	$51.29	$16.99	$34
10	Loveland	CO	44,300	744	$112	$0	$16	$128.00	$10.61	$117
11	Madison	WI	200,920	1,257	$115	$42	$3	$160.10	$12.65	$147
12	Portland	OR	503,000	1,437			$72	$196.00	$14.64	$181
13	St. Paul	MN	496,068	1,268			$34	$115.00	$0	$115
14	San Jose	CA	873,300	1,539			$7	$206.29	$0	$206
15	Seattle	WA	543,700	2,706			$30	$120.78		$121
16	Visalia	CA	92,677	1,009	$61	$29	$24	$114.19	$0	$114
17	Worcester	WA	169,759	1,696			$5	$54.06	$0	$54
		Min =	1,908		$7	$0	$1	$39	$0	$31
		Median =	92,677		$61	$14	$16	$115	$2	$115
		Max =	873,300		$115	$100	$75	$206	$17	$206
		Min if >0 =							$5	
		Median if >0 =							$12	
		Data count if >0 =							8	
		Percent of data >0 =							47%	

Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Household Density (n=17 municipality sample 1996)



Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Population (n=17 municipality sample 1996)



Appendix C:
Four Alternative EMRAD Study Plans (Options) for This Assessment

Alternative Approaches for Evaluating the Economic Feasibility (Benefits & Costs) of Achieving 35% National Goal for Municipal Solid Waste Recycling

Level of Effort	OPTION 1 Minimum data/analysis	OPTION 2 Enhanced data/analysis	OPTION 3 Expanded data research & analysis	OPTION 4 National economic benefit-cost analysis
Who performs work?	! EMRAD in-house (Eads) ! MISWD only transmits MSW data/info materials (reports, memos, spreadsheets) to EMRAD	! EMRAD in-house (Eads) ! MISWD supports EMRAD through in-house team meetings with EMRAD to inform/steer data collection and analysis	! EMRAD or contractor performs worktasks ! MISWD supports EMRAD on consultation basis such as for drafting supplementary pieces, and/or as WAM for contractor	! Contractor performs all worktasks ! EMRAD or MISWD directs/ reviews work as contractor W A M
FTE duration	! 2 to 4 weeks	! 4 to 8 weeks (depends upon level of data and info details discovered/desired)	! 8 to 12 weeks	! 16 to 36 weeks (or longer)
Data Collection	! MISWD staff MISWD provides EMRAD with relevant materials (e.g. EPA reports, internal memos, gray literature, etc), concerning MSW recycling in general, and concerning OSW 's 35% goal in particular	! EMRAD & MISWD staff (A) EMRAD conducts verbal interviews with MISWD staff to collect information on prior MSW recycling topics in general, and on OSW's 35% goal in particular (e g prior stakeholder meetings, prior conference calls with regions/ states, prior internal analyses, prior EPA studies, and prior published or gray literature studies by academics, NGOs, states, municipalities). (B) EMRAD participates in upcoming MISWD RIT conference call (25 March) (1) to describe OSW's new economic analysis project options concerning the 35% goal, and (2) to leverage regions for feedback/ suggestions/ inputs (an opinion poll approach)	! EMRAD in-house or contractor (A) Collect data as described in Option 2 (B) Search internet and published literature for additional materials relevant to MSW recycling economics	! Contractor (A) Collect extant data per Option 3 (B) Collect new data as necessary (e.g survey <10 entities each of municipal govt's, recycling companies, MSW collector companies) (C) Transfer or otherwise formulate reasonable assumptions to plug data gaps (numerical single point values or numerical uncertainty ranges)
Output	! EMRAD drafts 10 to 20 page briefing package containing inventory of information sources, data gaps, possible conclusions about 35% goal, and list of options for expanded economic analysis. ! MISWD reviews/ edits package ! EMRAD & MISWD present briefing to OSW management for decision about next step options.	! EMRAD drafts 10 to 50 page briefing package to present verbally to OSW management in early or late April 2003 meeting. ! MISWD reviews/ edits package ! Package contains overview of existing data/info & gaps, findings about economic feasibility of 35% goal, and any next steps for OSW management decision.	! EMRAD in-house or contractor Prepare a draft briefing package as described in Option 2, supplemented with extramural data/ information materials	! Contractor (A) Deliverable #1 Draft a comprehensive report (100 to 300 pages) describing data sources, methodology, findings, and recommendations of this study. (B) Deliverable #2 (optional) Draft a 10 to 50 page briefing package for use by EMRAD and MISWD to present the study findings and national policy options to OSW management.
Types of MSW recycling policy questions addressed	! What is origin/rationale behind OSW's 35% goal? ! What analytic options does OSW have to evaluate the 35% goal?	! Is the 35% goal economically feasible? ! Is there a more appropriate MSW recycling goal? ! What are OSW's policy options for achieving 35% (e g. which waste categories to target, how to provide market incentives)?	! What are the characteristics of the US national MSW recycling market(e g. tons/year recycled, count of recycling entities, waste types recycled, recycled material prices, recycling costs, recycling budgets, regional or major municipal differences in recycling market)?	! What are national aggregate annual benefits & costs associated with achieving the 35% goal? ! What are the disaggregate benefits & costs (e g by waste category, by reuse industry, by region, by major municipality), and associated feasible contribution towards the 35% goal? ! What are the technical constraints to the 35% goal? ! How many years may it take to achieve the 35% goal? ! What is the gap between private & social benefits/costs?